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MANUAL FOR DEICING CHEMICALS: APPLICATION PRACTICES

ARTHUR D. LITTLE, INCORPORATED

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This report contains the results of a study conducted for the U.S. Environmental Protection Agency to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Based on the best current practices for highway maintenance as observed during two years of study, practical guidelines are presented for the use of deicing chemicals.

1. Supervisory aspects of proper chemical usage are defined, including organization and personnel training.
2. Efficient snow and ice control requires good judgment and appropriate action. Elements of proper decision-making are discussed, including weather forecasting, setting chemical application rates, and accounting for chemical usage.
3. The backbone of winter road maintenance is equipment. General requirements and major equipment classes are described, including recent improvements and advantages or disadvantages. Methods are given for accurate spreader calibrations.
4. Means are described for developing and enlisting the support of citizens and drivers for winter road maintenance policies.
5. Legal requirements for and constraints on snow and ice control are described.

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment -- air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

The study described here was undertaken to minimize the amount of chemicals used in controlling snow and ice on highways. Practical guidelines are presented for good practices in the application of deicing chemicals.

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Director
National Environmental
Research Center, Cincinnati

ABSTRACT

This report contains the results of a study conducted for the U.S. Environmental Protection Agency to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Based on the best current practices for highway maintenance as observed during two years of study, practical guidelines are presented for the use of deicing chemicals.

1. Supervisory aspects of proper chemical usage are defined, including organization and personnel training.

2. Efficient snow and ice control requires good judgment and appropriate action. Elements of proper decision-making are discussed, including weather forecasting, setting chemical application rates, and accounting for chemical usage.

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4. Means are described for developing and enlisting the support of citizens and drivers for winter road maintenance policies.

5. Legal requirements for and constraints on snow and ice control are described.

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CONVERSION TO METRIC UNITS

In this Manual, all units are expressed in U.S. customary units. Conversion to metric units is easily accomplished by use of the following formulae:

Multiply miles by 1.6093 to get kilometers

Multiply tons by .9072 to get metric tons (10^3 kg)

Multiply cubic yards by .7646 to get cubic meters

Multiply pounds by .4536 to get kilograms

Multiply feet by .3048 to get meters

RECOMMENDATIONS AND SUMMARY

THE PROBLEM

State highway departments, turnpike authorities, municipal street departments, and other organizations (shopping centers, hospitals, schools) annually purchase approximately 9 million tons of salt and other deicing chemicals with a total value of about $140,000,000. As the amount of these materials has increased, so too has the concern for what these materials are doing to our environment.

Excessive use of material and loss of material before it can be used effectively provides several causes for concern. Chief among these, from the standpoint of the U.S. Environmental Protection Agency and its counterpart state agencies, is that environmental damage may result from water-borne salt. Much of the salt spread on roads eventually enters the various water courses either as direct run-off or by percolation into the groundwater system. There is evidence of road salt in private and public wells and surface reservoirs.

The U.S. Public Health Service recommends that drinking water not contain more than 250 mg/l of the chloride ion. Water of even low salinity has been known to cause corrosion problems in industrial plants. Although no federal standard for sodium in drinking water exists, one is currently being considered; however, the generally accepted warning level is 20 mg/l for patients restricted to low-sodium diets.

Cost is another concern. Salt and other deicing chemicals are expensive and, for reasons of economy, should be used effectively and sparingly. In addition to the direct costs, there are additional indirect costs that are borne partly by highway agencies in the form of corrosion damage to trucks and equipment and to bridge decks; for the most part, these delayed costs must be paid by other segments of the public in the form of rusted automobiles and degraded drinking water.

For these environmental and economic reasons, it is important that maintenance authorities use no more salt and other chemicals than are absolutely necessary to improve the driving conditions during winter storms. The problem is that excess amounts have been applied routinely. The causes include lack of awareness of the problem, lack of managerial controls over salt usage, lack of calibrated equipment, and lack of understanding and cooperation by the driving public.

Because of a concern for this excessive use of salt and other deicing chemicals, the EPA funded this program to investigate techniques for minimizing the loss to the environment of chemicals used in controlling snow and ice on highways. The charter of this two-year project was to study the best current practices for snow and ice control in highway maintenance and to develop practical guidelines for the use of deicing chemicals. The study immediately ran into two diverse points of view; from the environmentalist's point of view, no chemicals should be used and, from the point of view of improved driving conditions, an amount equal to or slightly in excess of an as-yet-to-be-determined minimum amount of chemical should be used. A premise of this study is that salt will continue to be used as the principal deicing chemical and that a compromise must be effected between the concerns of the environmentalists and those of the driving public.

A major finding in this study was a discrepancy between the prescribed amounts of deicing material and the amounts that are actually used on the highway surface. Many maintenance managers were aware of this and readily admitted that they were using more material in their operation than was actually prescribed by their maintenance manuals. Those managers who, for economic or environmental reasons, initiated actions to reduce the amount used to the prescribed levels found to their surprise and satisfaction that there was no reduction in the level of service provided by the lesser amounts of deicing chemicals. This finding provides the basis for the recommendations of this manual.

RECOMMENDATIONS

The recommendations of this manual include techniques--both technical and managerial--for reducing the amount of chemical used and discussion of areas in which further research efforts would be beneficial.

Techniques for reducing the amount of chemical used include:

- The use of ground-speed controllers for all spreaders.

- Calibration of spreaders to determine how much material is being used. Two techniques are presented; a yard calibration and an in-service calibration. Rule-of-thumb techniques are also presented for checking calibration and determining when spreaders are not operating at their prescribed rates.

- Establishment of levels of service. Standards for maintaining roads during the winter should vary according to road types and their average daily winter traffic.

- Establishment of a set of application rates for each agency. Guidelines are presented for the amount of chemicals to be applied under varying weather conditions for various classes of roads. Two distinct rates are prescribed: one for the first application and lesser amounts for secondary applications as the storm progresses.

- Starting to plow snow early in each storm and emphasis on plowing rather than salting. Underbody scrapers are recommended for keeping snow-pack from forming.

- Accounting for the amount of salt used on each section of highway or city street. A daily report filled out by each operator—summarizing the amounts of chemical used, the lane miles upon which it is used, and the results obtained—is essential for accurate accounting for chemical usage.

Effective snow and ice control hinges upon the leadership and decision making of the maintenance manager. Therefore, a strong recommendation of this study is that his importance in the organization be recognized and that he be given the training and resources necessary to do his job effectively. This manual is addressed specifically to the needs of maintenance managers at all levels of the organization from road crew foremen right up to superintendents and commissioners.

The major areas where additional research effort must be placed include:

- Improvement in the reliability of ground-speed controllers for metering the amount of deicing chemicals spread onto the roadway.

- Development, through carefully controlled experiments, of a sound basis for prescribing the minimum amount of chemicals and/or abrasives to be applied to road surfaces for various weather and traffic conditions.

THE INTENT OF THIS MANUAL

This manual seeks to help maintenance managers establish an operating balance between two important, but sometimes conflicting, public-policy goals—clear roads and clean water. It supplements the discussion and recommendations in a companion Manual for Deicing Chemicals: Storage and Handling (EPA-670/2-74-033). That manual focused on the relatively easy task of minimizing wastage during shipment and storage. This one addresses the more difficult task of reducing excessive application of salt onto roads and highways.

Above all, this manual is designed to be practical. Its recommendations embody the best current practices, as observed during many weeks spent with highway crews in snow-belt cities and states. Its recommendations recognize that snow conditions, types of equipment, traffic volumes, budgets, and other factors vary widely. It avoids exotic solutions that would require special equipment and large costs. It tries to respect operating requirements, as well as concern for environmental protection.

Some of what this manual recommends is becoming common practice. The several application rates and levels of service found in this manual are based upon, or are direct borrowings of, plans and descriptions reported by highway personnel, the Salt Institute, and researchers in publications, including state maintenance manuals; papers presented to the Transportation Research Board, the North American Snow Conference, the American Public

Works Association, and other technical and professional associations; and corporate and institutional publications.

What, then, is the unique contribution of this manual? Probably, it is valuable in several ways:

- Range. The manual covers all aspects of deicing chemical usage, from laws and regulations to choice of equipment and techniques for educating the driving public.
- Balance. The manual concerns itself equally with technical and managerial issues.
- Perspective. The manual draws upon a range of literature, as well as first-hand observation of field operations.
- Alternatives. The manual presents a range of tools--equipment, techniques, recommendations, and references--so that its users can derive operationally and environmentally satisfactory solutions suited to their particular needs and constraints.

In short, this manual tries to provide a complete, practical, down-to-earth guide for all levels of maintenance managers charged with using deicing chemicals effectively and responsibly.

SUMMARY

In the remainder of this discussion, the major areas covered in the manual are briefly introduced.

PART ONE: LEGAL AND REGULATORY FRAMEWORK

Until recently, maintenance managers have not needed to pay much attention to laws. But now, due to concern about chemical damage to the environment (especially to public drinking water supplies), the legal framework is changing and becoming more restrictive.

Several states have recently taken, or are now considering, laws to curb excessive use of salt. Although federal legislation has not yet addressed deicing chemicals directly, recent or pending laws on water pollution control and safe drinking water reflect growing public concern about damage to water supplies, and thus a potential future problem for highway maintenance managers. Moreover, states are following the federal lead in environmental legislation, including provisions encouraging active participation by citizens in policy planning and execution.

PART TWO: ADMINISTRATION AND SUPERVISION

Job descriptions of maintenance managers should be amended to reflect the broadened scope of their responsibilities beyond the traditional role of maintenance engineers. In light of these changes, maintenance supervisory training should include the basics of groundwater hydrology, environmental aspects of designing and maintaining roads, management techniques for accounting for salt usage, and procedures for complying with federal and state environmental protection laws.

The organization of the maintenance function can significantly influence its operational success. Winter maintenance cannot be managed effectively without considering maintenance requirements during other seasons. In small jurisdictions, one workforce may perform all road functions, including maintenance. But in large cities and states, the organizational position and prominence of maintenance can vary; it may be integrated with the design and construction tasks of field districts or it may be separated, with its own chain of command directly to top management. Maintenance in any context deserves attention and support by top managers in matters of policy, relations with the public, and allocation of budget resources. Maintenance managers who perform well merit recognition and promotion.

PART THREE: .OPERATIONS

Several critical elements in successful operation deserve particular attention:

- Weather warning with accuracy. This is the most important tool for decision making. The maintenance manager has access to all weather services — federal, independent (for a fee), local radio-T.V. stations, and neighboring highway departments in the storm's path.
- Planning of operation strategy through setting of appropriate levels of service for winter maintenance.
- Preparation for the winter season through detailed organization of the workforce and intensive crew training.
- Setting of chemical application rates in accordance with weather, traffic, and planned levels of service.
- Paying particular attention to environmentally critical areas through the use of minimum chemical techniques.
- Accounting for chemical usage by road section and analyzing the results obtained.

PART FOUR: EQUIPMENT REQUIREMENTS AND CALIBRATION

Guidelines are presented for the equipment required for snow and ice control operations based on the lane-miles to be serviced, number of interchanges, average spreader and plowing speeds, and levels of service. A variety of trucks, spreaders, blowers, loaders, graders, and plows are shown in photographs, with the text presenting their essential features, as well as advantages and latest innovations.

Ground-speed-controlled spreaders are the most important items of equipment for applying chemicals accurately. These devices allow dispensing only when the truck is in motion, and then only proportional to its speed, thus eliminating the wastage common today with independently controlled spreaders.

Calibration of spreaders is the most important action an agency can take to minimize excessive use of chemicals. Two techniques--yard calibration and in-service (over the road) calibration--are explained step by step, with calculations. Results for each truck are recorded on a card in the cab, for ready reference by the driver. Calibration measures should include not only the amount dispensed, but also the pattern and extent of the spread.

PART FIVE: PUBLIC PARTICIPATION

Three broad approaches exist for reducing excessive reliance on chemicals. The first, technical, is the most familiar and makes up most of this manual. The second, legal, has been emerging in recent years through the efforts of environmentalists and legislators. The third, education and persuasion of the driving public, is presently the least-used tool available to maintenance managers.

Managers can help influence driver behavior, and thus reduce their demands for excessive use of chemicals in several ways: by knowing the facts about chemical usage and environmental damages, by developing citizen awareness of environmental consequences, by showing their own concern, and by enlisting citizen support for sensible maintenance policies and budgets. The techniques described include speeches, press releases, pamphlets, telephone procedures, roadside signs, surveys, hearings, and citizen advisory groups.

These techniques should promote several messages. Citizens starting to drive should ask, "Is this trip really necessary?" Maintenance departments should offer and provide only service that is reasonable; the slogan "June travel in January" raises unreasonable expectations and incurs unreasonable costs. Bare roads are, by themselves, not necessarily safe roads, and maintenance departments are not solely responsible for highway safety. Citizen drivers are obliged to observe laws and regulations devised for the common good, such as laws that limit speed, designate snow routes, and establish levels of service.

PART ONE: LEGAL AND REGULATORY FRAMEWORK

CHAPTER I

LEGAL AND REGULATORY FRAMEWORK

In the past, maintenance managers have probably not had to pay much attention to questions of law and regulations, except to know that municipal ordinances may require citizens to clear sidewalks on their property. However, the legal and regulatory framework relating to snow and ice control is important. Furthermore, it is in the process of changing and developing. These changes will influence the way in which maintenance managers and their organizations work. Good managers must, therefore, be sensitive to them.

The assumption underlying this manual is that deicing chemicals and their use are only one part of a total system. This system may be described as "moving people and goods during bad winter weather." It includes many components, such as roads, cars, winter driving equipment on cars, weather and weather forecasting, snow-fighting organizations, and travelers and their drivers. Experience with this and other environmental problems shows that success depends upon attacking all components of a problem, not just a few. The system has, in addition to technical components treated elsewhere in this manual, important nontechnical components, including the legal-regulatory framework and the behavior of citizen travelers and drivers.

In this chapter, four aspects of the legal-regulatory framework are discussed.

- Common local snow removal ordinances,
- New state laws,
- Related federal laws, and
- Emerging environmental laws and regulations.

COMMON LOCAL SNOW REMOVAL ORDINANCES

Towns, villages, cities, and other municipal jurisdictions receive their writ of authority from one of the 50 states; their enabling legislation authorizes local jurisdictions to enact such ordinances, by-laws and regulations, "not repugnant to law, as they may judge most conducive to their welfare, which shall be binding upon all inhabitants thereof and all persons within their limits." (Massachusetts General Laws Chapter 40, section 21, given as a sample.)

By-laws and ordinances normally related to a variety of functions such as regulating sewers, preserving peace and good order, and protecting public drinking water supplies. In Massachusetts, towns may pass by-laws for preventing the fall of snow and ice from roofs, for providing for the removal of snow and ice from sidewalks, for requiring owners of buildings near public ways to take measures to prevent snow and ice from falling upon passing persons, and for authorizing the superintendent of streets to remove vehicles hindering the plowing of snow.

As awareness of the environmental side effects of chemicals increases, more local governments will probably enact by-laws or regulations to control their use. They may act independently or within the framework of new laws passed by their states. Ann Arbor, Michigan, acted in 1970, after a series of city-sponsored studies and public meetings, by passing an eight-point policy, which it published in a brochure to all citizen drivers; the complete brochure is reproduced in Chapter VII of this manual.

Maintenance managers should know the relevant laws or by-laws in their state or local jurisdictions. In addition to the by-laws cited above, some states and localities are now enacting environmental protection laws and by-laws that may affect the work of maintenance organizations. Maintenance managers should know their own obligations under these laws, the duties of citizens, and how to invoke the police powers of government to assist their work.

NEW STATE LAWS

Several states have recently taken, or are now considering, laws to protect their environment against contamination by deicing chemicals, New Hampshire anticipated the problem in 1959 and 1965, when its legislature authorized the state highway department to replace roadside wells contaminated by road salt. Two states acted in 1971. Minnesota's legislature enacted a statute which reads in part:

> "(160.215) HIGHWAYS: SNOW REMOVAL: USE OF SALT OR CHEMICALS RESTRICTED. In order to:
>
> (1) Minimize the harmful or corrosive effects of salt or other chemicals upon vehicles, roadways, and vegetation;
>
> (2) Reduce the pollution of waters; and
>
> (3) Reduce the driving hazards resulting from chemicals on windshields; road authorities, including road authorities of cities, villages, and boroughs, responsible for the maintenance of highways or streets during periods when snow and ice are prevalent, shall utilize such salt or other chemicals only at such places as upon hills, at intersections, or upon high speed or arterial roadways where vehicle traction is particularly critical, and only if, in the opinion of the road authorities, removal of snow and ice or reduction of hazardous conditions by blading, plowing, sanding,

> including chemicals needed for the free flow of sand, or natural elements cannot be accomplished within a reasonable time."

In Vermont, environmentally-minded legislators proposed legislation to change the state's standard of service from a "bare road" policy to a "safe road" policy. Out of discussion and debate with the Vermont Department of Highways, the following compromise resulted:

> "NO. R33. JOINT RESOLUTION RELATING TO THE BARE OR SAFE ROAD POLICY OF THE VERMONT DEPARTMENT OF HIGHWAYS.
>
> Whereas, the state of Vermont has attained and enjoyed over the years the enviable reputation for outstanding maintenance of its state highway system; and
>
> Whereas, this high quality of highway maintenance enhances and promotes the safety of the traveling public as well as the swift and efficient movement of goods into, within and from the state of Vermont; and
>
> Whereas, the state's economy and the continuing well-being of its citizens are dependent, in part, upon the immediate availability and use of the highway network; and
>
> Whereas, the immediate availability and use of the state highway system dictates a bare or safe road surface as soon as possible after inclement weather; and
>
> Whereas, the controlled use of chemicals has been proven from 30 years experience to be an effective method available to attain a bare or safe road surface; and
>
> Whereas, there has been evidence presented indicating that the excessive use of chemicals may be harmful to the environment; now therefore be it
>
> Resolved by the Senate and House of Representatives: That the department of highways is commended for their program of research for less potentially harmful methods of obtaining bare or safe roads, and be it further
>
> Resolved: That the department of highways be exhorted and encouraged to work with the Agency of Environmental Conservation in a continuing effort to discover methods of obtaining bare or safe roads which will be economically feasible and least harmful to the environment, and be it further
>
> Resolved: That the Agency of Environmental Conservation shall work closely with the highway department in accomplishing the foregoing purposes, and be it further

> Resolved: That the department of highways should continue to maintain a bare or safe road policy with appropriate adjustments determined advisable as a result of conducted research.
>
> Approved: March 29, 1971."

Two years later, Massachusetts enacted a stronger law, emphasizing storage but also providing authority to regulate application in special areas such as reservoir watersheds. Chapter 1208, Massachusetts Laws of 1973, amended Chapter 85 of the General Laws to include a new section:

> "Section 7A. No person shall store sodium chloride, calcium chloride or chemically treated abrasives or other chemicals used for the removal of snow or ice on roads in such a manner or place as to subject a water supply or ground-water supply to the risk of contamination. The department of public health, hereinafter called the department, in consultation with the department of public works, may issue regulations as to place or manner of storage of such chemicals and may, by specific order, in a particular case regulate the place where such chemicals may be used for such purpose. Any violation of this section or any regulation or order issued hereunder shall be punished by a fine not to exceed fifty dollars per day. Any person who uses more than one ton of such chemicals in any calendar year shall report annually to the department on November first, and at such other times as prescribed, the amount of such chemicals used in the previous twelve months specified by road section or other location and the amount of chemicals on hand. Copies of such reports shall be made available upon the request of any concerned state or municipal agency or commission. The department may require studies by competent professional personnel of the probable impact of proposed new or improved highways and the maintenance thereof by use of such chemicals upon reservoirs, ponds, streams, lakes, wetlands and the groundwater aquifers associated with both public and private water sources. Estimates of such chemicals to be applied on proposed roads and other paved areas shall be based upon the most recent records of chemicals actually applied as reported under the provisions of this section. The word "person" as used in this section shall include surveyors of highways, road commissioners, superintendents of streets in towns, commissioners of public works in cities and towns, the chief engineer of the state department of public works, the chief engineer of the Massachusetts Turnpike Authority, the chief administrative officer of state agencies and private persons, including corporations."
>
> "Section 2. The commissioner of the department of public health shall issue guidelines for the reporting of the amount of chemicals used in snow and ice removal, as required by section seven A of chapter eighty-five of the General Laws, inserted

> by section one of this act, prior to the effective date of this act."

The reasons which moved Massachusetts to pass this law are described in a recent book.[2]

In mid-1973, a legislative survey by Arthur D. Little[2] of 33 American snow-belt states found that most of them have no statutes or pending bills concerning deicing chemicals. Bills had recently been introduced but had failed to pass in Connecticut and Nevada. In Wisconsin, however, events were following the pattern of Massachusetts, as concern about environmental injury led to legislative hearings, reports, and the drafting of bills. Two strong measures were proposed in Wisconsin's General Assembly in January, 1974. The first, Assembly Bill 1401A, would establish strong controls for use of chemicals:

- Chemicals would have to be stored so as to prevent contamination of land and water.
- Chemicals would have to be used only where vehicle traction is critical, and then only when alternative methods are not adequate.
- Salt spreaders would have to be certified as being in good working order and properly calibrated.
- Snow and ice would not be dumped where the melt would flow into surface waters.
- Local governments would have to file annual reports of chemical use.
- Wisconsin's Highway Commission would have to prepare annually an environmental impact statement about chemical usage anticipated during the next year.
- The Department of Transportation would have to conduct research into alternative methods of snow and ice control.

The second, Assembly Bill 1402A, would require comprehensive study of the environmental effects of deicing chemicals in order to establish a baseline for continued monitoring.

Just as at the local level, maintenance managers at the state level must be aware of environmental protection laws which may affect their operations. In Vermont, for example, the state's water quality authorities require the Department of Highways to request and receive an annual permit before applying deicing chemicals which may degrade drinking water supplies. Similarly in other states, strong laws exist which public health authorities can invoke to protect drinking water supplies. Moreover, additional laws have recently been passed in some states, for example, to protect coastal and inland wetlands and other natural resources, which may be significant for maintenance operations.

RELATED FEDERAL LAW

Traditionally, the building and maintenance of roads and highways have been activities reserved to state and local governments. So, too, have the regulation of water supplies. However, recent activities in the Congress and by the Environmental Protection Agency foretell a more vigorous Federal role in years to come.

During the 1960's, the obviously declining quality of the nation's waters contributed greatly to the general concern for environmental degradation which became a major political issue in 1970. In 1965, Congress passed the Water Quality Act, which followed the traditional pattern of providing Federal encouragement and funds while leaving the basic initiative to state and local governments. However, they did not act with the desired vigor, and Congress therefore passed in 1972 the far-reaching Federal Water Pollution Control Act Amendments, which shifted leadership to the Federal government, set stringent goals for water quality by the mid-1980's, and authorized vigorous enforcement.

Three aspects of the 1972 law should concern maintenance managers. First, even though the Act does not apply explicitly to drinking water supplies, it does signal a growing and intense national awareness of the limits and fragility of our water resources. The Act applies to surface waters as they are used for fishing, swimming, and other recreation. Historically, surface waters and ground waters have been treated separately, both professionally and legally, even though they are not separated physically; however, it will only be a matter of time before the public recognizes generally the natural linkages between surface and ground waters and the role of deicing chemicals as a pollutant. Second, the Act requires participation by the public.

> Public Law 92-500, Section 101 (e) provides:
>
> "Public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under the Act shall be provided for, encouraged, and assisted by the Administrator and the States. The Administrator, in cooperation with the States, shall develop and publish regulations specifying minimum guidelines for public participation in such processes."

Third, the U.S. Environmental Protection Agency and the states are directed to actively seek, encourage, and assist the public in participating in this process of setting water quality requirements and monitoring them. To that end, Congress charged:

> "Information and Education Programs should be devised which will acquaint the public with the complexity of the water

> quality control process and provide them with the technical information. To accomplish this, the Environmental Protection Agency should look to the utilization and support of such devices as community workshops and other assistance activities which were developed and utilized so effectively in the implementation of the Clean Air Act." (Legislative history, Public Law 92-500, U.S. Code and Administrative News, 1972, page 3679. The steps chosen by EPA to implement this charge are presented in The Federal Register, Vol. 38, No. 163, August 23, 1973, pp. 22757-8.)

Consistent with the Act, a nationwide series of workshops addressed the more obvious kinds of contamination, such as raw sewage from towns or cities, chemical wastes from factories, and agricultural pesticides drained off from farmlands. They did not yet specifically include deicing chemicals as pollutants, but this will also be only a matter of time.

The systematic public participation required by this Act, as well as regulations governing review of environmental impact statements for highways and other projects, has not yet intruded into the world of maintenance managers. However, as environmental consciousness rises, as knowledge of water quality grows, as the public participation process becomes familiar, and as the potential dangers of deicing chemicals become widely known, maintenance managers can expect demands for public participation to rise, and perhaps even be required by law or regulation. Thus, maintenance managers would do well to follow the techniques that federal and state environmental protection officials develop for implementing public participation in water quality programs. Part Five, Chapter VII of this manual discusses many techniques for encouraging citizen education and cooperation.

In the context of national concern about water quality in general, it is not surprising that Congress is now considering the first federal law on drinking water during this century, the proposed "Safe Drinking Water Act." One bill has already been passed by the Senate; another and reportedly stronger version is being considered, in mid-1974, by the House Commerce Committee. It is not useful here to speculate in detail about the likely contents of the final Act. However, it seems probable that such a law will strengthen federal authority to establish minimum standards of quality for drinking water, standards which could significantly increase the concern of public health authorities about the use of deicing chemicals.

Federal guidelines for state public health authorities already exist in the Drinking Water Standards issued in 1962 by the U.S. Public Health Service. Its recommended maximum level of chloride of 250 mg/l led Massachusetts public health authorities recently to close three public wells and to voice their concern about rising chloride levels in several more. The Standards do not, however, present recommendations concerning sodium, the chemical element which concerns physicians treating patients for high blood pressure (hypertension) and other diseases of the heart and blood vessels. One reason is that awareness by the medical community of possible harmful effects of sodium was not wide-spread in the early 1960's; but awareness has increased significantly in recent years. Revisions of the Standards are now being considered; the criteria proposed in October 1973 by a public advisory group retain the limit of 250 mg/l of chloride but suggest no level for sodium; however, the final document is reported likely to include, for the first time, a thorough discussion of sodium and its importance. Here again, it is not useful to try to predict the revised standards, and how they might affect maintenance managers. Our purpose, instead, is to draw attention to their significance for maintenance managers.

EMERGING ENVIRONMENTAL LAWS AND REGULATIONS

As the preceding sections suggest, the rate of change in recent years in the field of environmental law and regulation has been rapid. This pace may continue for some time. Therefore, this manual cannot pretend to keep maintenance managers up-to-date on the legal-regulatory framework in all states and local jurisdictions. It can, however, urge maintenance managers to remain aware of these developments which may affect their work.

Some states are currently following the lead of the federal government in passing their own legislation which supplements, and in some cases goes beyond, federal statutes. Maintenance managers should remind general counsels or legislative representatives of highway maintenance organizations (states, local governments, and special districts such as turnpike authorities and park commissions) to review new statutes and regulations and advise how these may affect maintenance operations. For example, some states have adopted environmental policy acts, modeled on the National Environmental Policy Act of 1969, which include provisions written in broad language. Some states have also passed citizen right-of-action statutes which confer upon individual or small groups of citizens legal standing to sue governments for improper performance of duties; previously, the right to allege wrong-doing and to bring suit was limited to persons or organizations which had sustained injuries for which they sought relief and payment of damages. States have also strengthened and broadened the citizen's right to know about governmental operations, including the right of easy access to information contained in public documents. Massachusetts, and perhaps other states, recently amended its constitution to include a broad environmental bill of rights, guaranteeing to citizens the right to enjoy such natural resources as clean air and water. Massachusetts also initiated the "ten-citizen procedure," by which ten or more citizens can petition a government agency to conduct a public hearing, for example, related to implementing a law or setting standards, or petition a court to intervene against a government agency whose actions threatened injury to the environment.

Statutes are not the only source of legal authority. Administering agencies normally issue regulations needed to translate a statute into effect. The courts are regularly asked to decide cases, which become precedents used in the interpretation of statutes and regulations. One example occurred in Massachusetts in early 1974, when the Commonwealth's Supreme Judicial Court backed the legislature's recent environmental legislation. The case (S-7844, February 27, 1974) arose from a dispute between the City of Boston and the Massachusetts Port Authority (Mass Port). The Authority is a public corporation, created by the state legislature to provide a variety of public services, such as operating the city's airport, following principles of business rather than governmental management; such authorities or special districts, numerous and often economically powerful, exist in many states and cities to operate turnpikes, tunnels, bridges, parks, and airports, many of which have roads requiring wintertime maintenance. One question at issue in this case was whether Mass Port was required, in view of its special status, to comply with certain provisions of recent environmental legislation. The Court ruled unanimously that all authorities must so comply. The lengthy opinion has, as the justices recognized, far-reaching implications, both for other authorities and for future interpretation of certain statutory requirements, such as assessing the environment impact of proposed new construction. The Chief Justice wrote that the result of Mass Port's interpretation would be that "a small group of state authorities would have a unique exemption from the regulatory power of the state, an exemption available to no person or legal entity, public or private." In short, authorities are subject to state laws on environmental matters. Although this decision applies only within Massachusetts, the legal argument supporting it could well be followed by courts in other jurisdictions.

PART TWO: ADMINISTRATION AND SUPERVISION

CHAPTER II

SUPERVISION REQUIREMENTS

The use of deicing chemicals has many technical aspects, and much of this manual focuses on technical questions. However, the problem of proper use of deicing chemicals is not just technical; it is also influenced by such factors as leadership, management or the lack of management, public attitude, and behavior of equipment operators. The many suggestions set forth in this manual depend for their effectiveness, of course, upon the cooperation and outlook of many highway maintenance employees. They take their cues, in both technical and policy matters, from their supervisors who, even to the top level, must clearly endorse and support a policy of using a minimum amount of environmentally harmful chemical materials to improve winter driving conditions. These cues should be explicit and unequivocal. This section points out those aspects of proper chemical use in which supervision is crucial.

Although a number of specific comments and recommendations are made in this manual, one general point should precede all discussions. Leadership in general, and supervision of chemical usage, which is merely one aspect of highway maintenance, is by its nature not a separate commodity or function. It cannot be bought in packages and it cannot be contracted to others. It is not the task of one man only; nor is it a full time task performed by a staff specialist. Instead, responsibility for proper usage of deicing chemicals is only one of the many assignments of maintenance supervisors. Ideally, they should be knowledgeable about a number of specific topics described in this manual. Although those maintenance managers and supervisors who have been trained professionally as engineers may feel more comfortable reading the sections focused on technical questions, their roles as supervisors or managers require them to pay attention to the non-technical aspects of maintenance, especially if they wish to perform their jobs successfully. They should, therefore, probably pay special attention to those parts of this manual with which they feel least familiar.

THE MAINTENANCE MANAGER

Our choice of terms needs a word of explanation. "Maintenance manager" is used throughout this manual to designate the key public works officials exercising decision-making power in the chain of command responsible for controlling snow and ice on winter roads. In a town or small city, the superintendent of roads or public works (who may also be the town manager or administrator) usually functions also as the maintenance manager in direct control of storm operations. The larger the jurisdiction, the more likely is the delegation of this function to a separate and subordinate official who specializes in maintenance, as distinct from engineering, road construction, research and planning, and other functions common to large highway or street departments.

In many or perhaps most cases, maintenance chiefs are professionally trained and experienced as engineers; indeed, in some jurisdictions, they carry the title of "maintenance engineer." But we prefer the term "manager" because it emphasizes that maintenance supervisors must have not just the technical skills associated with the term "engineer" but also several coordinating and judging skills:

- For mobilizing men as well as machines
- For directing complex operations
- For managing budgets
- For representing the maintenance function to various sectors of public, as well as to other functions within the highway or public works department.

Moreover, the title "manager", even when held by an engineer, reflects the change and broadening that normally occurs later in an official's career, as he grows beyond his early technical training and assumes a wider range of responsibilities. Finally, the term recognizes that the use of snow-fighting techniques so as to minimize harm to the environment requires judgments that are not solely engineering in character; they are managerial because they require compromises or trade-offs among competing criteria or goals (such as service to motorists, financial efficiency, environmental protection, and adherence to policy and regulations). Because of such considerations, Connecticut's Bureau of Roads recently adopted the concept and title, for example, "District Maintenance Manager", as part of a general reorganization, noted below.

Sometimes we use "maintenance manager" to refer specifically to the chief maintenance supervisor; at other times, we broaden it to include all supervisors, from commissioners or superintendents to foremen of road crews, whose jobs require some independent exercise of judgment. Whether superior or subordinate in the chain of command, these supervisors influence the total effect of a department's snow and ice control effort, and, therefore, share in the managerial responsibility for success or failure. Which use of the term we intend in each instance will be clear from its context.

This manual is written in phrases familiar to highway maintenance personnel of state or city departments. But it is addressed to maintenance managers responsible for roadways of private organizations as well, including hospitals, universities, schools, cemetaries, and commercial establishments such as shopping plazas, truck depots, and company or factory parking lots. In time, all may find themselves regulated to greater or lesser degree by state or local laws seeking to prevent further chemical contamination of the environment, especially public drinking-water supplies.

The maintenance manager is caught these days in a tough dilemma. First of all, he has the responsibility to maintain the roads in his jurisdiction in good repair and in driveable conditions. He is caught between the expectations of the driving public who increasingly wants, and often demands, June-in-January roads, and the environmentalists who are concerned with the rapid deterioration of some water supplies through the excessive use of deicing chemicals. Often, the maintenance manager, as an individual and inhabitant of planet earth, shares both of these feelings. As a maintenance manager, however, he is also beholden to his immediate superiors to perform his job within his allotted budget, which is often interpreted in terms of minimum manpower, equipment, energy, and, of course, expensive chemicals such as salt and calcium chloride.

In order to adjust and clarify the duties of managers for responsible use of deicing chemicals, their formal job descriptions should be revised to include the following points:

1. Develop policies and procedures for applying chemicals, to meet environmental as well as engineering requirements, drawing upon expert assistance as necessary from headquarters and research staffs.

2. Develop or assemble environmental baseline data required for planning and possible environmental impact statements. Essential baseline data would include groundwater information and annual reports of its sodium and chloride levels (expressed in "milligrams per liter", which is the same as "parts per million"), which should be obtainable from public health authorities. Without such baseline data as a background, effects of various management practices, for good or for bad, cannot be measured objectively.

3. Be responsible for, or assist in, cooperative relationships with other governmental agencies concerned, for example, about environmental or public health aspects of usage.

4. Ensure proper adherence to policies and procedures, checking, for example, the periodic calibration of spreaders and recording of operating data.

5. Supervise periodic instruction of maintenance workers in environmentally safe handling of salt and other deicing chemicals during loading, application, and cleaning up after storms.

6. Perform frequent on-the-spot inspections during winter operations to observe actual usage practices and take steps to improve sub-standard practices.

7. Design and ensure proper use of the department's system for reporting usage of deicing chemicals, for purposes both of efficient management and of preventing use of salt in excess of established standards.

8. Review periodic chemical usage reports, interpret them as necessary to higher authority, other government agencies, and the general public; when indicated by abnormal reports, take corrective actions to improve usage and handling practices.

9. Consult with design and construction engineers when building or improving roads to ensure consideration of features (e.g., drainage ditches) needed generally to facilitate and specifically to minimize entry of deicing chemicals into the environment.

Supervising maintenance managers are presumed to be mid-career officials, with time to participate in only occasional in-service training courses. Such courses, perhaps a few days in length, should include at least three kinds of teaching techniques: formal instruction, problem-solving exercises, and field observation.

Formal instruction should include consideration of two basic areas: (1) special engineering topics and (2) environmental protection requirements and procedures. Special engineering topics should include groundwater hydrology; environmental aspects of planning, design, construction and maintenance of roads; and winter operations where salt and other chemicals are used. Environmental quality topics would vary from state to state, but generally include discussions of federal and state environmental laws, implementing requirements prescribed by the Federal Highway Administration and the state highway agency, and finally specific procedures for complying with those requirements, for example holding public hearings, developing possible environmental impact statements, developing programs for minimizing chemical usage, and meeting regular reporting requirements.

Formal instruction should always be accompanied by a variety of problem-solving exercises which are tailored to the topics and manner of presentation. For example, trainees might be asked to select and evaluate groundwater hydrological data, to identify and rank techniques for minimizing chemical usage, to draft portions of an environmental impact statement required by a state, or to develop operations procedures which will minimize the use of chemicals.

Formal instruction and problem-solving exercises should be complemented by opportunities for observation in the field. Trainees might visit and inspect DPWs noted for good usage practices; observe or even assist in the instruction of maintenance workers prior to the winter season, observe a department's work on an environmental impact statement, or observe a public or interdepartmental hearing on proposed chemical usage policies.

Although the formal aspects of supervising a maintenance team are important, the practical behavioral problems should not be overlooked. The many requirements and suggestions presented in the manual may suggest that the critical actors, namely the operators and drivers on the road, are ideal employees--well-motivated, well-paid, taking pride in their work, technically skilled, and concerned only with minimizing environmental effects of chemical use. In reality, these ideal men exist rarely. Moreover, managers in public service have only limited use of those major tools of reward and punishment--pay raises, promotions, and dismissal. However, they can still find ways of motivating their subordinates. In general, they must protect them from pressures and interference from outsiders, fight within the DPW for needed budget and equipment, and represent them vigorously in personnel questions. Managers should improve working conditions in the little ways which count, for example by providing radios in truck cabs, hot coffee and food at depots during nighttime storm operations, and inexpensive help (for example high school boys seeking work) for routine jobs such as breaking up caked salt and sweeping up trucks and pads after loading. Specific employees can be rewarded by assigning them to preferred routes, the newest equipment, and more desirable jobs. Managers should tour their areas regularly during storms, both to inspect operations and to provide that personal, on-the-spot leadership required by any team working under pressure. By techniques such as these, managers can help to overcome deficiencies in equipment and budget while influencing the behavior of their subordinates.

ORGANIZATIONAL CONTEXT

To plunge right into the heart of our problem and all of its technical aspects is tempting. But first, it is both useful and necessary to review its context; indeed, the problem has arisen largely because we have concentrated on technical improvements in maintenance while paying little or no attention to its effects on its environmental context. Other aspects of context are equally important. Vermont's Commissioner of Highways, John T. Gray, argues that the management of winter maintenance cannot be examined intelligently without considering maintenance management during other seasons. For example, unlike managers of private businesses, managers of government agencies are subject to civil service regulations which, in effect, restrict their flexibility in hiring and laying off workers as seasonal needs change. Moreover, efficiency requires that equipment be purchased, wherever possible, for multiple uses and during all seasons.

Equally important for the function of maintenance is its organizational context. Maintenance, whether performed by an all-around crew in small towns or by a special division within a state's DPW, both influences and is influenced by other parts of its parent organization, such as personnel, purchasing, construction, planning, and financial management. Moreover, beyond its own department, it influences and is influenced by other agencies of government, including the town manager or mayor or governor, the town meeting or city council or state legislature, the budget or fiscal office, and lately the public health or natural resources authorities. A significant part of any manager's job is to understand the relationships between his division and other organizational units and to manage them effectively.

Figure 1 represents how the maintenance function fits within the government of a town or a small city. Wintertime maintenance is performed by a small organization, which also handles all other road building tasks. For large cities, of course, the organizational structure resembles that of states, where size dictates separate field districts and specialization of functions.

Figure 2 shows schematically two kinds of organization at the state level. The difference is in how functions are organized in the field districts. First, the left-hand side of Figure 2 shows the integrated field district, in which maintenance is only one of several functions, all supervised by the District Engineer, who reports directly to the Chief Engineer; in this structure, policies and technical assistance from state headquarters reach the District Maintenance Engineer only through his District Engineer, who may or may not be sympathetic to the problems and requirements of wintertime maintenance. Second and by contrast, the right-hand side of Figure 2 shows a state organization where maintenance is organized separately. This structure was adopted recently by Connecticut's Bureau of Highways. Previously, Maintenance was grouped with and often subordinate to Design and Construction, despite the fact that it now requires the largest proportion of personnel and a substantial budget. The preeminence of Design and Construction probably reflected the expansion of highway building during the 1960's, especially construction of the interstate system, which therefore naturally offered more opportunities for promotion. By contrast, the maintenance function suffered in various ways, especially in haphazard personnel promotion practices. With the reorganization in 1972, Connecticut first restricted transfers among divisions to lower level jobs only and second, promoted maintenance managers only from within the newly separated Maintenance Division. No form of organization is free of problems of coordination. Often, organizational charts and their formal chains-of-command are merely ideal and rational pictures; in practice, leadership and effective communication ebbs and flows in response to physical proximity, personal compatibility, and other influences. However, the separate structure shown in Figure 2 moves the maintenance function closer to the top manager of the highway department; it thereby offers better chances of success in competition for budget and personnel; and it presumably also offers better career opportunities, always an important attraction for men of talent.

The symbolism of this separated form of organization should not be overlooked. It emphasizes that long-term maintenance can be as important as initial layout and construction of roads, even though it is a routine housekeeping function. Moreover, it suggests that maintenance policies are a concern of top management, and that their understanding and support is important for success. Finally, it places the maintenance manager somewhat closer to his ultimate customers, the various groups within the driving public.

Figure 3 presents the organizational context in a different way. It centers on the maintenance manager, whether in a small or large jurisdiction. It retains the hierarchy or chain of command above and below him. But it

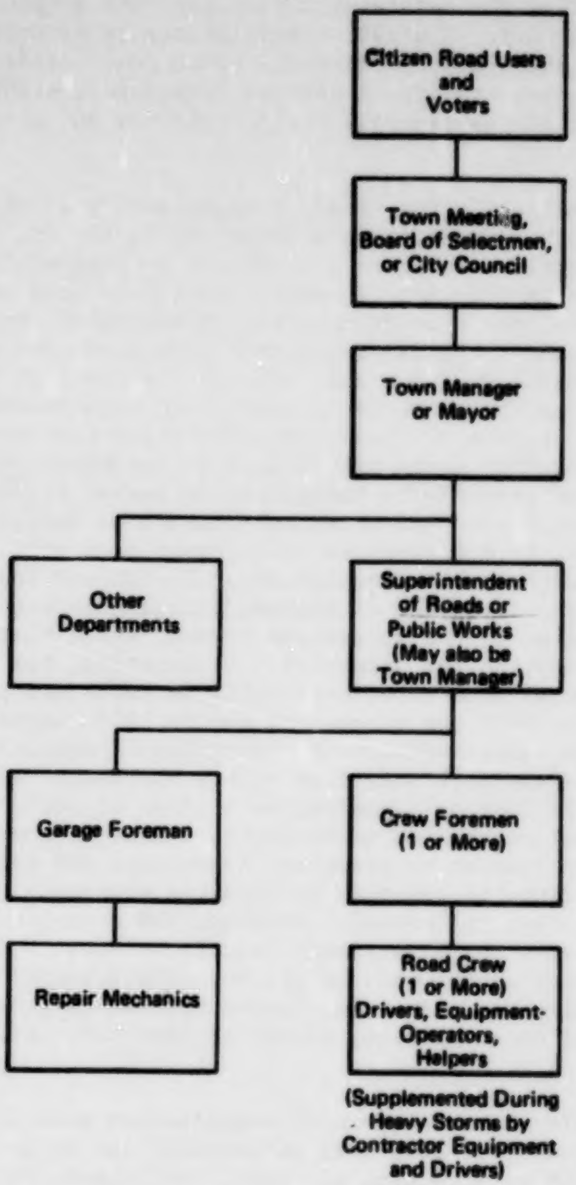
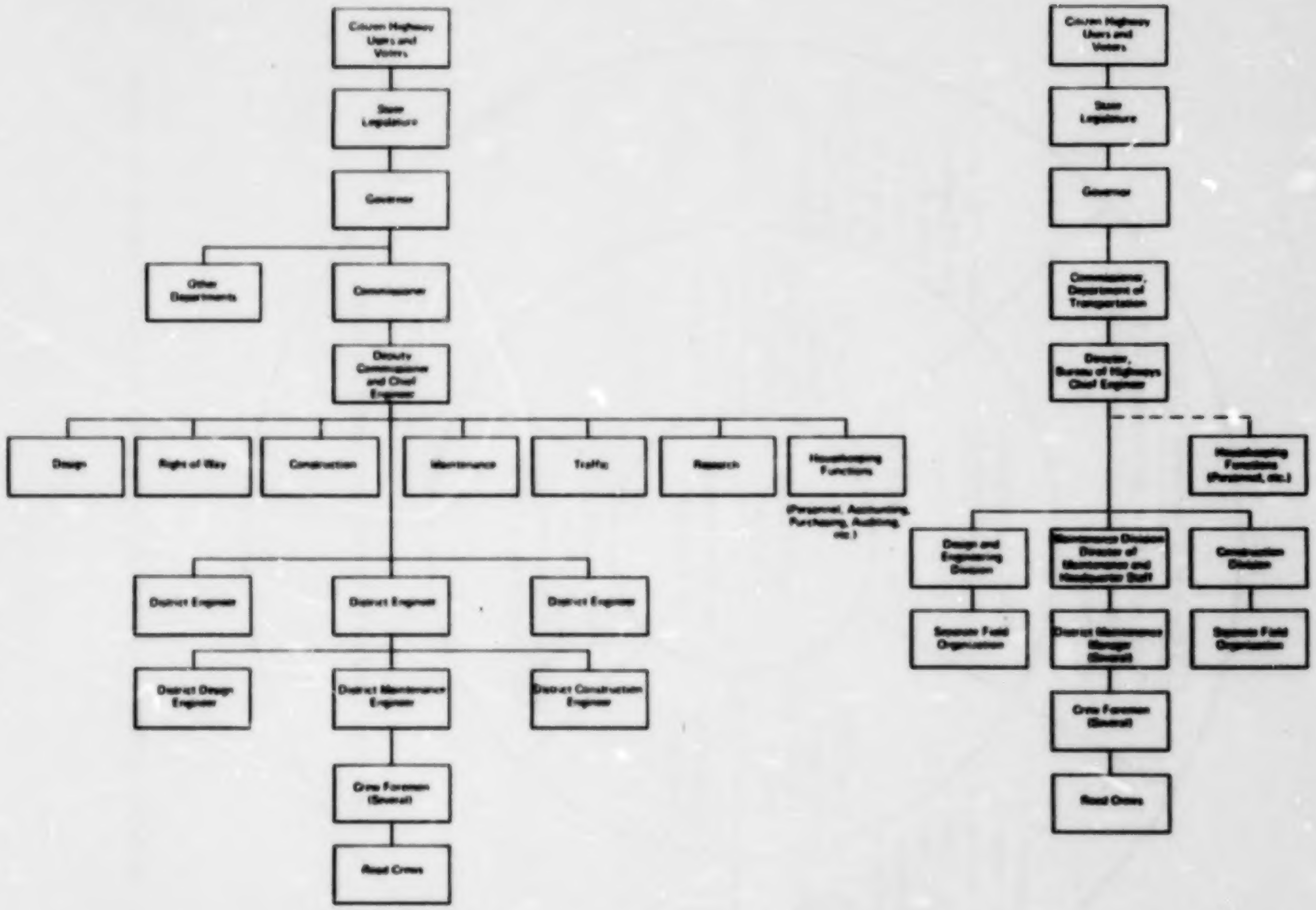

Citizen Road Users and Voters
Town Meeting, Board of Selectmen, or City Council
Town Manager or Mayor
Other Departments
Superintendent of Roads or Public Works (May also be Town Manager)
Garage Foreman
Crew Foremen (1 or More)
Repair Mechanics
Road Crew (1 or More) Drivers, Equipment-Operators, Helpers
(Supplemented During Heavy Storms by Contractor Equipment and Drivers)

FIGURE 1 **ORGANIZATION OF TOWN OR CITY MAINTENANCE FUNCTION** **(Winter Maintenance only One of Many Functions Performed by a Small Staff)**


Citizen Highway Users and Voters
State Legislature
Governor
Other Departments
Commissioner
Deputy Commissioner and Chief Engineer
Design
Right of Way
Construction
Maintenance
Traffic
Research
Housekeeping Functions
(Personnel, Accounting, Purchasing, Auditing, etc.)
District Engineer
District Engineer
District Engineer
District Design Engineer
District Maintenance Engineer
District Construction Engineer
Crew Foremen (Several)
Road Crews
Citizen Highway Users and Voters
State Legislature
Governor
Commissioner, Department of Transportation
Director, Bureau of Highways Chief Engineer
Housekeeping Functions (Personnel, etc.)
Design and Engineering Division
Maintenance Division Director of Maintenance and Headquarter Staff
Construction Division
Separate Field Organization
District Maintenance Manager (Several)
Separate Field Organization
Crew Foremen (Several)
Road Crews

INTEGRATED FIELD DISTRICTS, INCLUDING MAINTENANCE FUNCTION, IN A STATE HIGHWAY DEPARTMENT

SEPARATE FIELD MAINTENANCE DISTRICTS WITHIN A STATE HIGHWAY DEPARTMENT

FIGURE 2 ORGANIZATIONS OF STATE HIGHWAY DEPARTMENTS

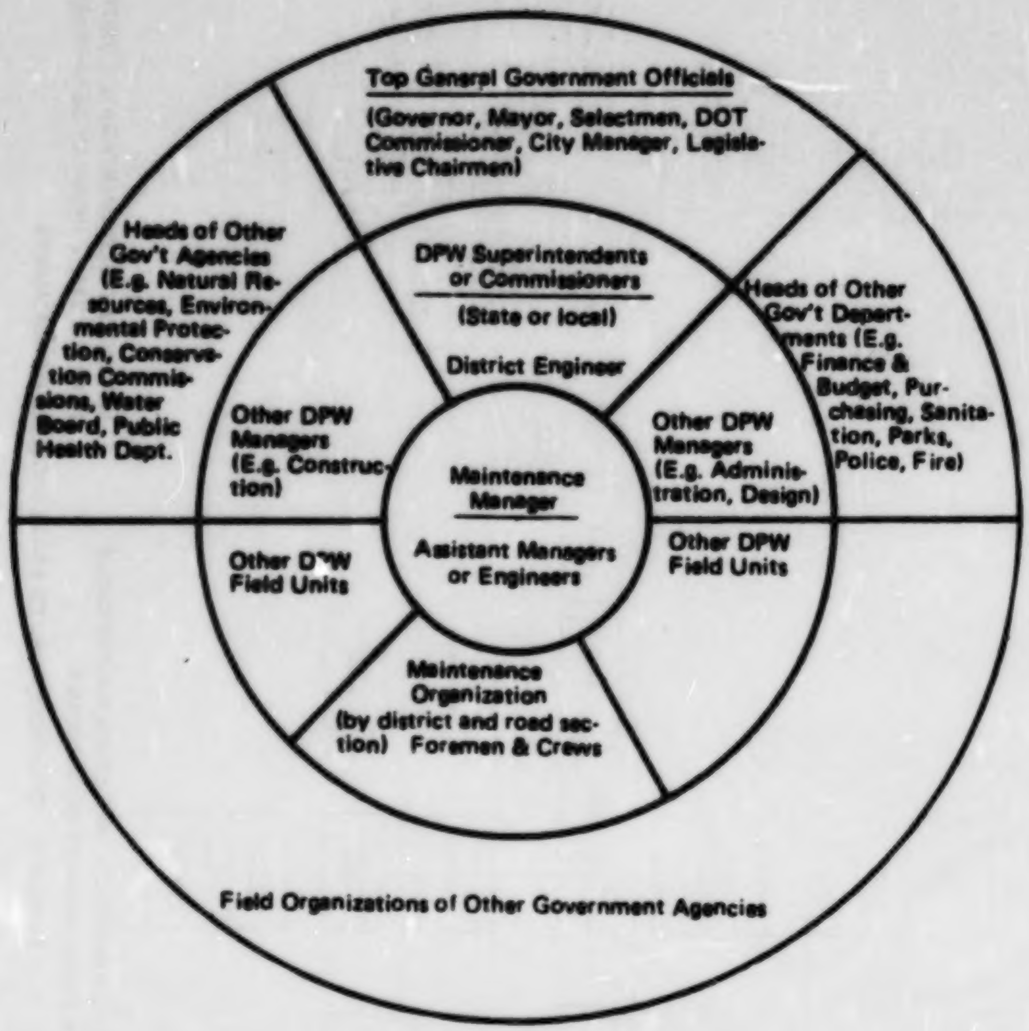

Top General Government Officials
(Governor, Mayor, Selectmen, DOT Commissioner, City Manager, Legislative Chairmen)
Heads of Other Gov't Agencies (E.g. Natural Resources, Environmental Protection, Conservation Commissions, Water Board, Public Health Dept.
Heads of Other Gov't Departments (E.g. Finance & Budget, Purchasing, Sanitation, Parks, Police, Fire)
DPW Superintendents or Commissioners
(State or local)
District Engineer
Other DPW Managers (E.g. Construction)
Other DPW Managers (E.g. Administration, Design)
Maintenance Manager
Assistant Managers or Engineers
Other DPW Field Units
Other DPW Field Units
Maintenance Organization
(by district and road section) Foremen & Crews
Field Organizations of Other Government Agencies

FIGURE 3 ORGANIZATIONAL CONTEXT AS VIEWED BY THE MAINTENANCE MANAGER

also suggests how relationships radiate out from him to other organizational units, both within the DPW and in other government agencies. Later in Part Five, Chapter VII, we shall add more concentric circles to suggest the maintenance manager's relationships with other important groups outside of government.

Although this manual seeks to report best current practices observed in a variety of highway and public works departments, its generalized format is not intended to obscure the realities of differences among various jurisdictions--state, county, city, town, and private institutions. Although geographical size and organizational structure vary, the principles of responsible chemical usage remain basically the same.

Large cities, for example, resemble states in needing a departmental organization with distinct and specialized units, and a chain of command. Although a city's area may have somewhat less variation in weather than a state, differing conditions within short distances remain a problem. A city's more compact area can allow close and more frequent personal inspections by managers, and thus somewhat tighter supervision of chemical usage during winter storms. However, truck drivers must still be left some discretion in applying chemicals according to local conditions.

Small cities and towns offer the best conditions for personal observation and control by the maintenance manager, who may also be the DPW superintendent and even town manager. However, such managers may be subject to more personal and direct pressures, from influential merchants, as well as from environmental advocates and from DPW road workers. Moreover, they may lack the specialized equipment and training available to large city or state departments. But their more intimate knowledge of a smaller area may permit them to strike a better balance among such competing goals as high-quality service, low-cost operations, and environmental protection.

Despite the variations imposed by these differences among jurisdictions, it is important that service on roads passing through more than one jurisdiction be consistent. This is to avoid sharp changes in road conditions, which may surprise motorists and help cause accidents.

PART THREE: OPERATIONS

CHAPTER III

TOOLS FOR DECISION-MAKING

Maintenance managers responsible for snow and ice control are faced with a number of decisions when storms become imminent. In most instances, these decisions must be made in the face of conditions that re continually changing and under pressure from local interest groups. To assist in making these decisions, these maintenance managers must have the best possible, up-to-date information about the storm and traffic conditions. The starting point for all such decisions is the weather forecast.

WEATHER WARNING

The most important asset of maintenance managers is a dependable source of knowledge about the timing, magnitude, and duration of each storm so that men, equipment, and material can be deployed and used in the most efficient way. Each organization must establish to its own satisfaction, a procedure or combination of techniques for finding out what the weather will do in their jurisdiction. Sources of information for alerting snow and ice control operations are numerous:

- National Weather Service of the National Oceanic and Atmospheric Administration (NOAA);
- Independent Weather Forecasting Services, such as Northeast Weather Service in Bedford, Mass., and Murray and Trettle in Chicago, Ill.;
- Local Television and Radio Station Meteorologists;
- Independent Meteorologists; and
- Neighboring snow and ice control groups located along the storm's path.

All weather services have access to the same meteorologic data. It is the interpretation of these data, and translation of them into useful weather forecasts which is crucial.

National Weather Service of NOAA

The federal government provides weather forecasting services through the National Weather Service, NOAA, U.S. Department of Commerce, (formerly the U.S. Weather Bureau). Weather Service offices, maintained at most municipal airports, provide generalized hourly weather forecasts for the immediate surrounding area. These forecasts are communicated in three different ways.

- Telephone: usually a recorded transcription is updated hourly. Since the forecast format is usually the same, it is convenient to formulate a data sheet onto which the weather data can be transferred when a telephone call is made. Sometimes local radio and television stations receive forecasts directly from the National Weather Service at specified times during the day. Other stations use only selected parts of the National Weather Service forecast.

- Continuous transmission over VHF/FM radio stations at 162.55 or 162.40 Megahertz. A special receiver is required for these transmissions. These stations are located only in large metropolitan areas and have an effective transmission range of only 40-60 miles. Forecasts are repeated every 4-6 min and are revised every 2-3 hrs.

- An aviation-oriented forecast by the Federal Aviation Administration (surface weather is also reported) through a transcribed weather broadcast service (TWEB): broadcasts are in the 200-400 Kilohertz AM frequency range depending on location (although a special receiver is required, a small portable radio can be easily modified to receive these signals[3]).

Independent Meteorologic Forecasting Services

Many organizations subscribe to an independent meteorologic forecasting service that provides up-to-the-minute weather information. The independent meteorologic service can provide several important services above and beyond that provided by the National Weather Service:

- Individualized forecasting for specific localities. The National Weather Service covers only large areas within the immediate vicinity of the forecasting offices.

- Updated forecasts on an hourly or more frequent basis depending upon how a storm is developing.

- Direct telephone contact by the subscribers with the meteorologists who are making the forecast at any time night or day, 24 hours per day, seven days a week.

As with any large meteorologic service, continuous weather observations and data are received over connections to the government weather teletype network and the facsimilie network. Situations are spotted as they develop, and according to the judgment of the forecaster, warnings are issued to subscribers as necessary. Some subscribers receive regularly scheduled weather forecasts, others on an unscheduled basis depending upon the weather. The typical weather forecast for snow and ice warning can be either in the form of an alert or in the form of a storm warning. Typically, a storm alert is put out in the afternoon before 3:30 or 4:00 p.m. when the maintenance people go home. This gives the regular day crew a chance to prepare equipment for a night storm and to alert or schedule crews for a night storm duty.

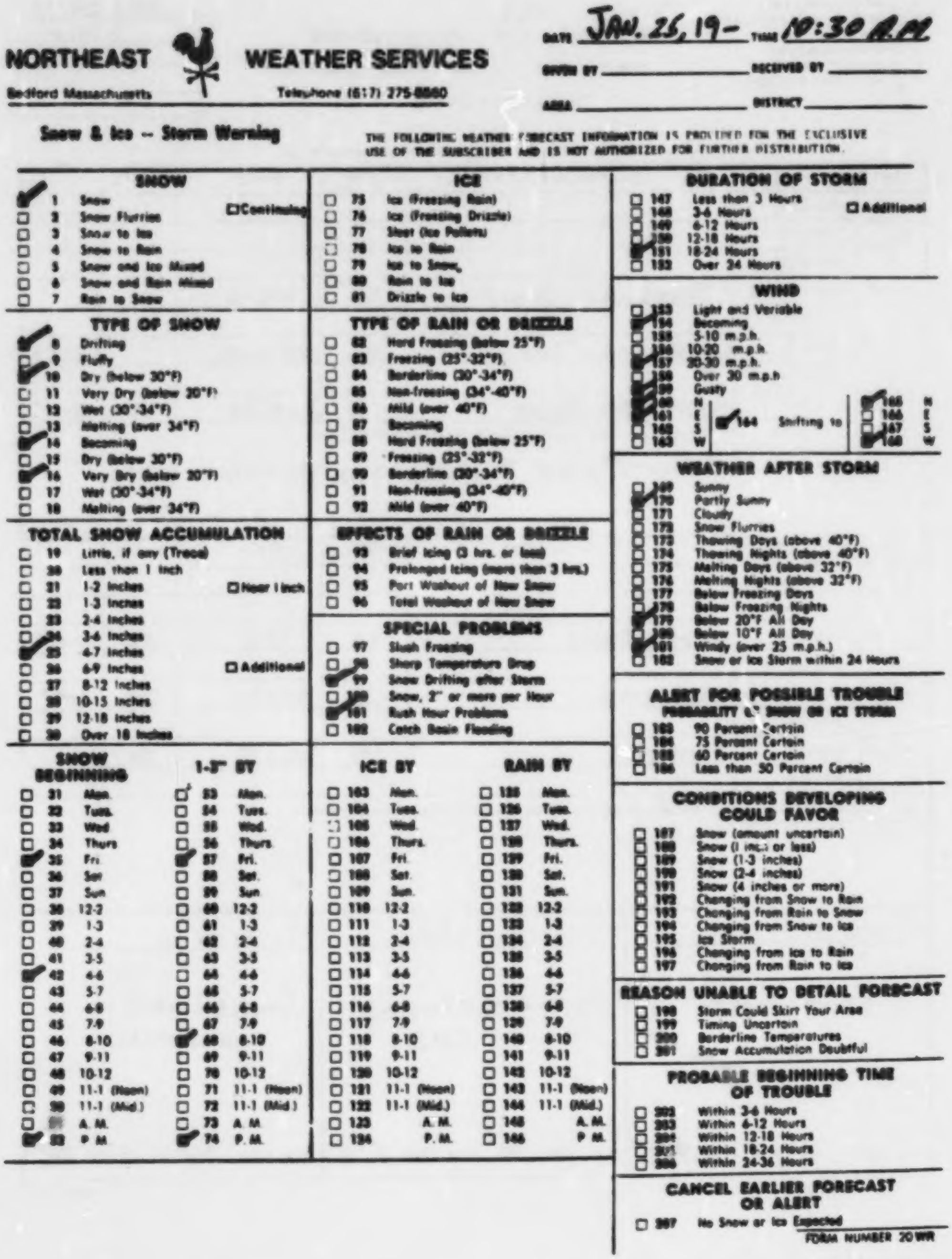
From 4 to 6 hr before a storm is expected to begin, the independent weather service will telephone the following detailed information to subscribers:

- the approximate hour the storm will begin;
- the type and amount of precipitation expected;
- the duration of the storm;
- the temperatures, wind direction and velocity, and drifting conditions during and after each storm;
- the approximate hour of change from snow to rain, ice to rain, snow to ice, etc.; and
- weather conditions to be expected after the storm, particularly whether the temperature will go up or down.

Details of this information are transmitted by phone and recorded on forms similar to the one shown in Figure 4. The subscriber has a large number of these forms, which he fills out when called by the weather service. Transmission of the information in numerical form saves time and prevents possible errors. For storms beginning during the night, subscribers are called before 4:00 p.m. the previous afternoon with details of the forecast at that time. If details are unobtainable before about 4:00 p.m., an alert is telephoned in lieu of the detailed forecast. This same procedure is generally followed for storms which are expected to begin over the weekend.

For large subscribers such as the Massachusetts Department of Public Works, specialized forecasts are prepared. These may be transmitted over teletype to the subscriber who cuts a transcription tape of his own for transmission over a closed-circuit teletype system to major road divisions. For other large subscribers, the information may be transmitted by facsimilie. From this type of weather forecast, a specific weather map can be drawn for the particular locality of the subscriber like the New Jersey Turnpike, which has considerable variation in weather conditions from one end to the other. For other subscribers, an extended weather forecast can be provided as on the form shown in Figure 5.

The independent weather service emphasizes direct communication with maintenance managers. Individual subscribers can call the independent weather service at any time and consult with the forecasting meteorologist who is on duty at the time. This two-way communication is as important to the forecaster as it is to the subscriber. The forecaster can pinpoint exactly



NORTHEAST WEATHER SERVICES
Bedford Massachusetts
Telephone (617) 275-8860

DATE JAN. 26, 19- TIME 10:30 A.M.
GIVEN BY ____ RECEIVED BY ____
AREA ____ DISTRICT ____

Snow & Ice -- Storm Warning

THE FOLLOWING WEATHER FORECAST INFORMATION IS PROVIDED FOR THE EXCLUSIVE USE OF THE SUBSCRIBER AND IS NOT AUTHORIZED FOR FURTHER DISTRIBUTION.

SNOW
- ☑ 1 Snow ☐ Continuing
- ☐ 2 Snow Flurries
- ☐ 3 Snow to Ice
- ☐ 4 Snow to Rain
- ☐ 5 Snow and Ice Mixed
- ☐ 6 Snow and Rain Mixed
- ☐ 7 Rain to Snow

TYPE OF SNOW
- ☑ 8 Drifting
- ☐ 9 Fluffy
- ☑ 10 Dry (below 30°F)
- ☐ 11 Very Dry (below 20°F)
- ☐ 12 Wet (30°-34°F)
- ☐ 13 Melting (over 34°F)
- ☑ 14 Becoming
- ☐ 15 Dry (below 30°F)
- ☑ 16 Very Dry (below 20°F)
- ☐ 17 Wet (30°-34°F)
- ☐ 18 Melting (over 34°F)

TOTAL SNOW ACCUMULATION
- ☐ 19 Little, if any (Trace)
- ☐ 20 Less than 1 inch
- ☐ 21 1-2 Inches ☐ Near 1 inch
- ☐ 22 1-3 Inches
- ☐ 23 2-4 Inches
- ☐ 24 3-6 Inches
- ☑ 25 4-7 Inches
- ☐ 26 6-9 Inches ☐ Additional
- ☐ 27 8-12 Inches
- ☐ 28 10-15 Inches
- ☐ 29 12-18 Inches
- ☐ 30 Over 18 Inches

SNOW BEGINNING			1-3" BY		
☐	31	Mon.	☐	53	Mon.
☐	32	Tues.	☐	54	Tues.
☐	33	Wed.	☐	55	Wed.
☐	34	Thurs.	☐	56	Thurs.
☑	35	Fri.	☑	57	Fri.
☐	36	Sat.	☐	58	Sat.
☐	37	Sun.	☐	59	Sun.
☐	38	12-2	☐	60	12-2
☐	39	1-3	☐	61	1-3
☐	40	2-4	☐	62	2-4
☐	41	3-5	☐	63	3-5
☑	42	4-6	☐	64	4-6
☐	43	5-7	☐	65	5-7
☐	44	6-8	☐	66	6-8
☐	45	7-9	☐	67	7-9
☐	46	8-10	☑	68	8-10
☐	47	9-11	☐	69	9-11
☐	48	10-12	☐	70	10-12
☐	49	11-1 (Noon)	☐	71	11-1 (Noon)
☐	50	11-1 (Mid.)	☐	72	11-1 (Mid.)
☐	51	A. M.	☐	73	A. M.
☑	52	P. M.	☑	74	P. M.

ICE
- ☐ 75 Ice (Freezing Rain)
- ☐ 76 Ice (Freezing Drizzle)
- ☐ 77 Sleet (Ice Pellets)
- ☐ 78 Ice to Rain
- ☐ 79 Ice to Snow
- ☐ 80 Rain to Ice
- ☐ 81 Drizzle to Ice

TYPE OF RAIN OR DRIZZLE
- ☐ 82 Hard Freezing (below 25°F)
- ☐ 83 Freezing (25°-32°F)
- ☐ 84 Borderline (30°-34°F)
- ☐ 85 Non-freezing (34°-40°F)
- ☐ 86 Mild (over 40°F)
- ☐ 87 Becoming
- ☐ 88 Hard Freezing (below 25°F)
- ☐ 89 Freezing (25°-32°F)
- ☐ 90 Borderline (30°-34°F)
- ☐ 91 Non-freezing (34°-40°F)
- ☐ 92 Mild (over 40°F)

EFFECTS OF RAIN OR DRIZZLE
- ☐ 93 Brief Icing (3 hrs. or less)
- ☐ 94 Prolonged Icing (more than 3 hrs.)
- ☐ 95 Part Washout of New Snow
- ☐ 96 Total Washout of New Snow

SPECIAL PROBLEMS
- ☐ 97 Slush Freezing
- ☐ 98 Sharp Temperature Drop
- ☑ 99 Snow Drifting after Storm
- ☐ 100 Snow, 2" or more per Hour
- ☑ 101 Rush Hour Problems
- ☐ 102 Catch Basin Flooding

ICE BY			RAIN BY		
☐	103	Mon.	☐	125	Mon.
☐	104	Tues.	☐	126	Tues.
☐	105	Wed.	☐	127	Wed.
☐	106	Thurs.	☐	128	Thurs.
☐	107	Fri.	☐	129	Fri.
☐	108	Sat.	☐	130	Sat.
☐	109	Sun.	☐	131	Sun.
☐	110	12-2	☐	132	12-2
☐	111	1-3	☐	133	1-3
☐	112	2-4	☐	134	2-4
☐	113	3-5	☐	135	3-5
☐	114	4-6	☐	136	4-6
☐	115	5-7	☐	137	5-7
☐	116	6-8	☐	138	6-8
☐	117	7-9	☐	139	7-9
☐	118	8-10	☐	140	8-10
☐	119	9-11	☐	141	9-11
☐	120	10-12	☐	142	10-12
☐	121	11-1 (Noon)	☐	143	11-1 (Noon)
☐	122	11-1 (Mid.)	☐	144	11-1 (Mid.)
☐	123	A. M.	☐	145	A. M.
☐	124	P. M.	☐	146	P. M.

DURATION OF STORM
- ☐ 147 Less than 3 Hours ☐ Additional
- ☐ 148 3-6 Hours
- ☐ 149 6-12 Hours
- ☐ 150 12-18 Hours
- ☑ 151 18-24 Hours
- ☐ 152 Over 24 Hours

WIND
- ☐ 153 Light and Variable
- ☑ 154 Becoming
- ☐ 155 5-10 m.p.h.
- ☐ 156 10-20 m.p.h.
- ☑ 157 20-30 m.p.h.
- ☐ 158 Over 30 m.p.h
- ☑ 159 Gusty
- ☑ 160 N
- ☑ 161 E
- ☐ 162 S
- ☐ 163 W
- ☑ 164 Shifting to
- ☑ 165 N
- ☐ 166 E
- ☐ 167 S
- ☑ 168 W

WEATHER AFTER STORM
- ☐ 169 Sunny
- ☑ 170 Partly Sunny
- ☐ 171 Cloudy
- ☐ 172 Snow Flurries
- ☐ 173 Thawing Days (above 40°F)
- ☐ 174 Thawing Nights (above 40°F)
- ☐ 175 Melting Days (above 32°F)
- ☐ 176 Melting Nights (above 32°F)
- ☐ 177 Below Freezing Days
- ☐ 178 Below Freezing Nights
- ☑ 179 Below 20°F All Day
- ☐ 180 Below 10°F All Day
- ☑ 181 Windy (over 25 m.p.h.)
- ☐ 182 Snow or Ice Storm within 24 Hours

ALERT FOR POSSIBLE TROUBLE
PROBABILITY OF SNOW OR ICE STORM
- ☐ 183 90 Percent Certain
- ☐ 184 75 Percent Certain
- ☐ 185 60 Percent Certain
- ☐ 186 Less than 50 Percent Certain

CONDITIONS DEVELOPING COULD FAVOR
- ☐ 187 Snow (amount uncertain)
- ☐ 188 Snow (1 inch or less)
- ☐ 189 Snow (1-3 inches)
- ☐ 190 Snow (2-4 inches)
- ☐ 191 Snow (4 inches or more)
- ☐ 192 Changing from Snow to Rain
- ☐ 193 Changing from Rain to Snow
- ☐ 194 Changing from Snow to Ice
- ☐ 195 Ice Storm
- ☐ 196 Changing from Ice to Rain
- ☐ 197 Changing from Rain to Ice

REASON UNABLE TO DETAIL FORECAST
- ☐ 198 Storm Could Skirt Your Area
- ☐ 199 Timing Uncertain
- ☐ 200 Borderline Temperatures
- ☐ 201 Snow Accumulation Doubtful

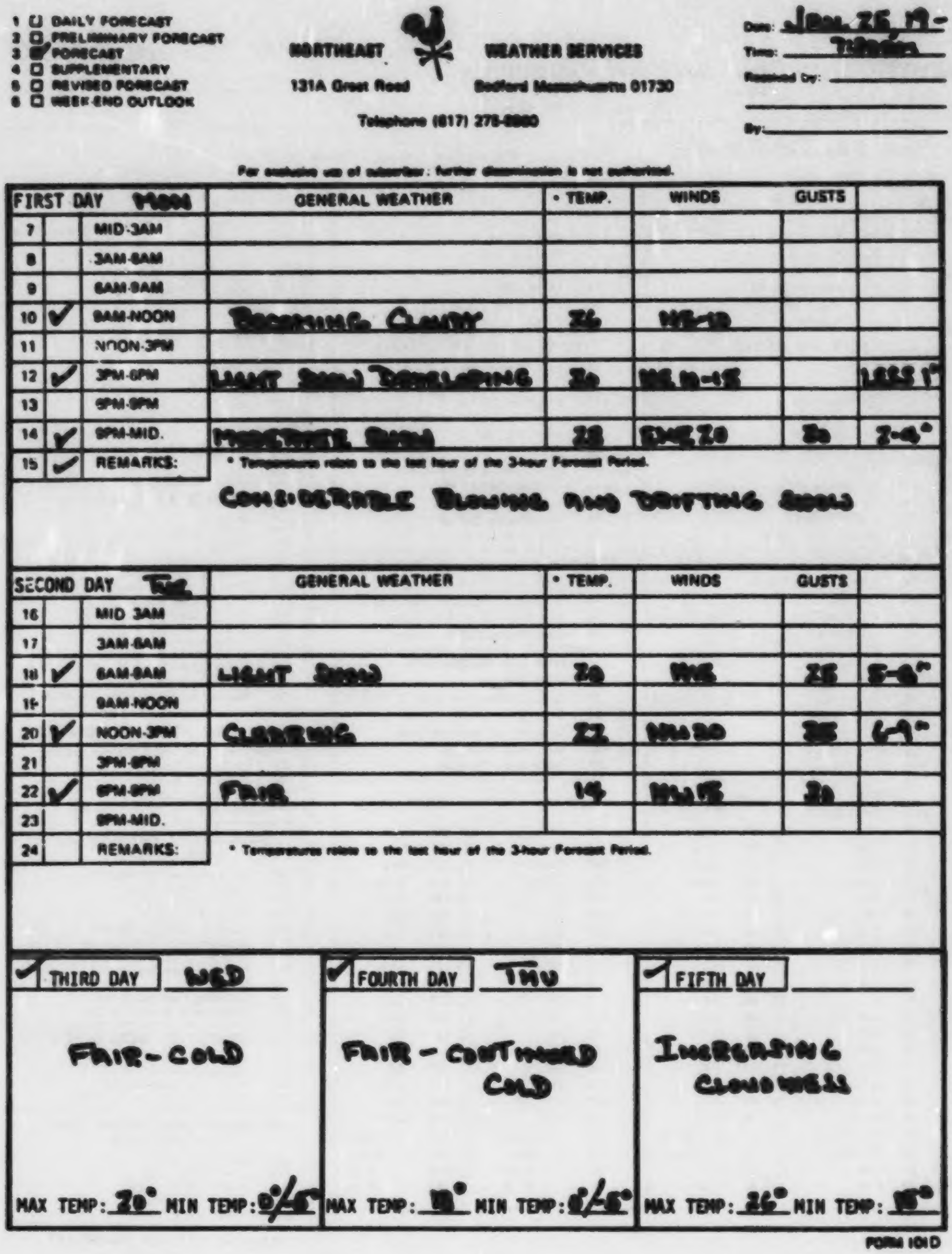
PROBABLE BEGINNING TIME OF TROUBLE
- ☐ 202 Within 3-6 Hours
- ☐ 203 Within 6-12 Hours
- ☐ 204 Within 12-18 Hours
- ☐ 205 Within 18-24 Hours
- ☐ 206 Within 24-36 Hours

CANCEL EARLIER FORECAST OR ALERT
- ☐ 207 No Snow or Ice Expected

FORM NUMBER 20WR

Courtesy of Northeast Weather Services,
Bedford, Massachusetts.

FIGURE 4 WEATHER REPORTING FORM



1 ☐ DAILY FORECAST
2 ☐ PRELIMINARY FORECAST
3 ☑ FORECAST
4 ☐ SUPPLEMENTARY
5 ☐ REVISED FORECAST
6 ☐ WEEK-END OUTLOOK

NORTHEAST WEATHER SERVICES
131A Great Road Bedford Massachusetts 01730
Telephone (617) 275-8860

Date: JAN 26, 19-
Time: 7:30am
Received by:
By:

For exclusive use of subscriber: further dissemination is not authorized.

FIRST DAY MON			GENERAL WEATHER	* TEMP.	WINDS	GUSTS	
7		MID-3AM					
8		3AM-6AM					
9		6AM-9AM					
10	✓	9AM-NOON	BECOMING CLOUDY	26	NE-10		
11		NOON-3PM					
12	✓	3PM-6PM	LIGHT SNOW DEVELOPING	30	NE 10-15		LESS 1"
13		6PM-9PM					
14	✓	9PM-MID.	MODERATE SNOW	28	ENE 20	30	2-4"
15	✓	REMARKS:	* Temperatures relate to the last hour of the 3-hour Forecast Period. CONSIDERABLE BLOWING AND DRIFTING SNOW				

SECOND DAY TUE			GENERAL WEATHER	* TEMP.	WINDS	GUSTS	
16		MID 3AM					
17		3AM-6AM					
18	✓	6AM-9AM	LIGHT SNOW	30	NNE	25	5-6"
19		9AM-NOON					
20	✓	NOON-3PM	CLEARING	22	NW 20	35	6-9"
21		3PM-6PM					
22	✓	6PM-9PM	FAIR	14	NW 15	30	
23		9PM-MID.					
24		REMARKS:	* Temperatures relate to the last hour of the 3-hour Forecast Period.				

✓ THIRD DAY WED	✓ FOURTH DAY THU	✓ FIFTH DAY
FAIR-COLD	FAIR - CONTINUED COLD	INCREASING CLOUDINESS
MAX TEMP: 20° MIN TEMP: 0/-5°	MAX TEMP: 10° MIN TEMP: 0/-5°	MAX TEMP: 26° MIN TEMP: 15°

FORM 101D

Courtesy of Northeast Weather Services,
Bedford, Massachusetts.

FIGURE 5 EXTENDED WEATHER FORECAST

what is happening during a storm and sharpen the local forecast in that area. This technique is particularly useful for prediction of changes in storm conditions as a storm passes between regular observation stations. It also gives the subscriber a chance to make his feelings known particularly when the weather is not what is forecasted.

A listing of independent weather services can be found in the bulletin of the American Meteorological Society, 45 Beacon Street, Boston, Massachusetts.

Local Television and Radio Stations

Many local radio and television stations maintain staff meteorologists who, with access to the standard government weather information, provide general weather forecasts for the local area served by the particular station. These forecasts are often used in conjuntion with other forecasting sources in formulation of an overall picture of the weather situation confronting the local snow and ice control group.

Other Sources of Weather Information

1. Sometimes independent meteorologists are employed to provide the precise weather predictions required of snow and ice control operations.

2. A telephone call to a neighboring highway organization may provide the required warning of snow conditions descending upon the area.

3. Often times through monitoring of a radio station in an adjacent state, sufficient warnings of snow conditions can be obtained particularly when storms follow traditional weather patterns. Supervisors of the western sections of the Massachusetts Turnpike regularly tune in on a Hartford, Connecticut radio station, which has a weather report that they find reliable.

TRAFFIC CONDITIONS AND LEVEL OF SERVICE

Two other major factors in decisions about snow and ice control are the traffic conditions that will exist at predicted start of the storm, during the storm, and at the end of the storm and the level of service to be maintained on the various classes of roads. The time at which storm conditions begin to develop has an important bearing upon the response and each group must establish a set of priorities to be followed as storms develop. (It is essential to give these priorities wide publicity so that the driving public will understand what is happening and give their support by staying home or avoiding lower serviced roads.)

Priorities for level of service should be based on traffic volume because it reflects the degree of difficulty in snow and ice control, the speed of vehicles using the roads, and the skill and familiarity of the highway users traveling on these roads. Volume of traffic also reflects the number of people that will be inconvenienced by deteriorating road conditions. Often, level of service priorities are established (quite validly) by experience or tradition. Minnesota, Michigan, Washington, New York, Nova Scotia, and other jurisdictions have established levels of service based on average daily traffic (ADT). The levels of service used in Minnesota are given in Table 1. Levels of service will be used in this manual as the basis for standards for snow and ice control, rate of application of chemicals and abrasives, and allocations of equipment and manpower. The recommended generalized priority system includes the four classifications of roads in Table 2. The guidelines for levels of service in Table 2 are a distillation of information from all of the above sources and can serve as a stepping off point for the preparation of levels of service suited to each particular location.

Table 1. LEVELS OF SERVICE FOR SNOW AND ICE CONTROL

Courtesy of Minnesota Department of Highways

Classification	ADT	Level of Service*
Urban Commuter	Over 10,000	Bare pavement within 6 hours after termination of storm (12 hours for severe storms). .
Rural Commuter	2,000-10,000	Bare pavement within 24 hours after termination of storm. (On divided highways, left lanes should be half bare with sanded curves and hills before termination of snow removal effort.
Primary	800-2,000	Intermittent bare pavement, clear Wheel Tracks (compacted snow with appropriate sanding allowed in towns and sheltered areas).
Secondary	400-800	Two bare wheel tracks and sanded hills and curves.
Secondary	250-400	Bare left wheel track and sanded hills and curves.
Secondary	Under 250 & Gravel Roads	Compacted snow is acceptable.

*Based on an average snowstorm of four inches falling in a six to eight hour period. Standards apply only to the mainline and interchange roadways; frontage road, crossover and other clean-up operations are not included.

Table 2 GUIDELINES FOR LEVELS OF SERVICE IN SNOW AND ICE CONTROL

Road Classification	Level of Service	Snow Depth to Start Plowing (Inches)	Max. Snow Depth on Pavement (Inches)	Full Pavement Clear of Snow After Storm (Hours)	Full Pavement Clear of Ice After Storm Hours
1. Low-Speed Multilane Urban Expressway	• Roadway routinely patrolled during storms • All traffic lanes treated with chemicals • All lanes (including breakdown lanes) operable at all times but at reduced speeds • Occasional patches of well-sanded snow pack • Roadway repeatedly cleared by echelons of plows to minimize traffic disruption • Clear pavement obtained as soon as possible	0.5 to 1	1	1	12
2. High-Speed 4-Lane Divided Highways Interstate System ADT greater than 10,000	• Roadway routinely patrolled during storms • Driving and passing lanes treated with chemicals • Driving lane operable at all times at reduced speeds • Passing lane operable depending on equipment availability • Clear pavement obtained as soon as possible	1	2	1.5	12
3. Primary Highways Undivided 2 and 3 lanes ADT 500 -- 5000	• Roadway is routinely patrolled during storms • Mostly clear pavement after storm stops • Hazardous areas receive treatment of chemicals or abrasive • Remaining snow and ice removed when thawing occurs	1	2.5	2	24
4. Secondary Roads ADT less than 500	• Roadway is patrolled at least once during a storm • Bare left-wheel track with intermittent snow cover • Hazardous areas are plowed and treated with chemicals or abrasives as a first order of work • Full width of road is cleared as equipment becomes available	2	3	3	48

CHAPTER IV

ACTIONS

Up to this point, this manual has been concerned with the regulatory frameworks, the supervision requirements, and some of the decision-making processes that lead up to snow and ice control operations. This chapter is written for the highwaymen (the equipment operators, the foremen, and the supervisors) who get out into the storm and do the work. It deals with organization of operations, pre-season training and equipment inspection, mobilization of men and equipment, issuing of orders, guidelines for application of deicing chemicals, and precautions to be taken in handling of deicing chemicals and loading spreader trucks. It discusses the role of the spreader operator, techniques for minimizing chemical applications, and accounting procedures for keeping track of the use of chemicals.

BEING PREPARED

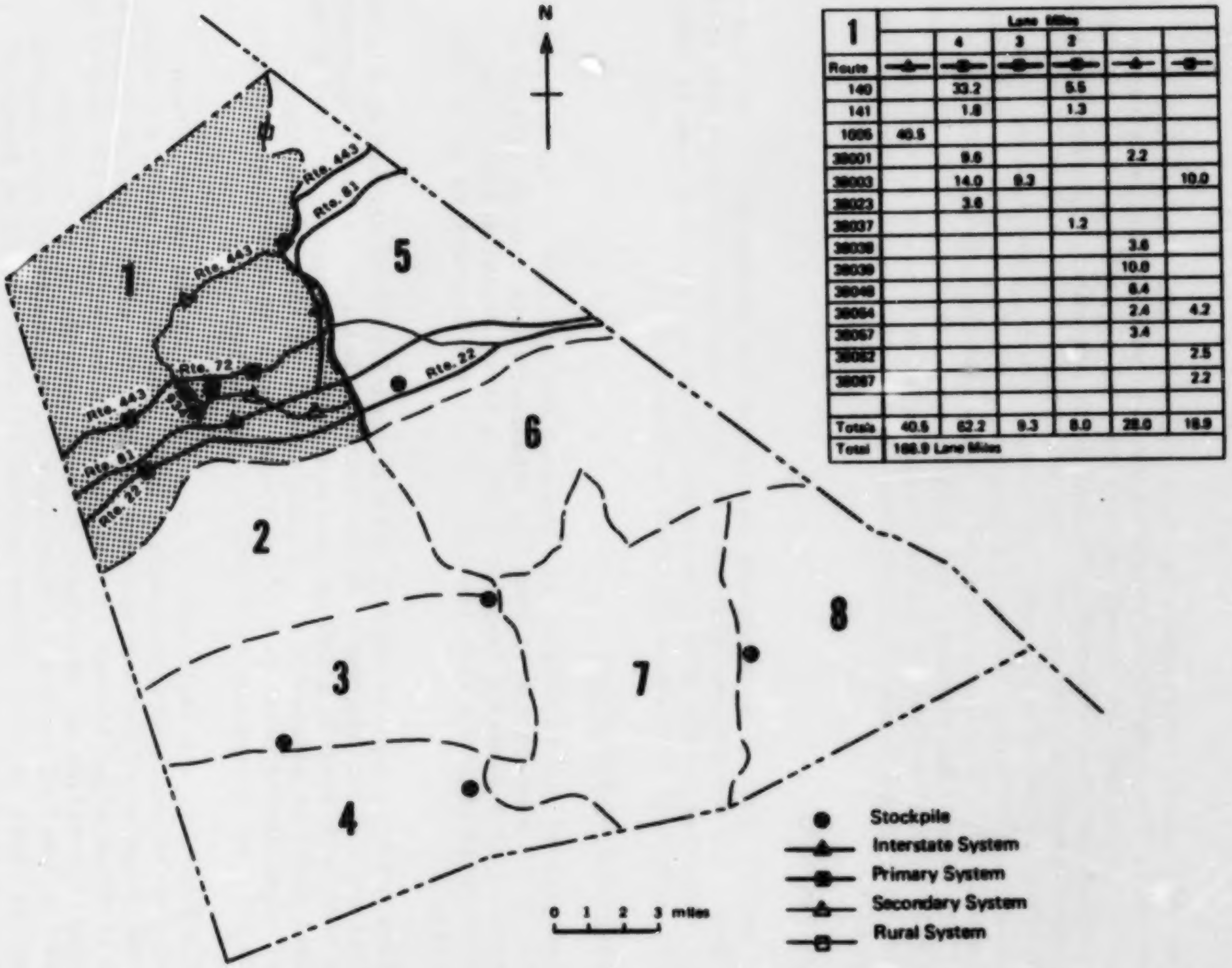
An important part of snow and ice control is the preparation of men and equipment for the actions that must be taken when weather conditions turn bad. Essential to the effective program is an organization that is responsive to the levels of service established in Chapter III.

Organization of Operations

As was pointed out in Chapter II, the work organization at the district level is the same no matter what the organization (a town or city or an integrated or a separate function within a state organization). The activities at this district level are of primary interest to us in this Chapter.

Uniform criteria must be used in establishing levels of service standards throughout the jurisdiction. At the district level it is highly recommended that both work breakdown and man and equipment assignments be based on an overall level of service plan. A good example of this is the district-level organization developed by the Pennsylvania Department of Transportation (Penn DOT) and reproduced here with its permission.

Within Penn DOT, the basic unit of organization is the county. Each county, which contains approximately 1,000 lane miles of road, is broken up into a number of foreman sections, such as the eight shown in Figure 6. Each of these eight foreman sections contains approximately 120 lane-miles of road, classified as interstate, primary, secondary, or rural and rated for level of service in that order. For simplified presentation, detail is shown for only foreman section 1. Color coding of levels of service as used by Penn DOT instead of the symbol codes shown here, increase the ease with which these planning maps can be read during storm operations.


N
1
2
3
4
5
6
7
8
Rte. 443
Rte. 81
Rte. 72
Rte. 22
0 1 2 3 miles
● Stockpile
▲ Interstate System
■ Primary System
△ Secondary System
□ Rural System

1	Lane Miles					
		4	3	2		
Route	▲	■	■	■	△	□
140		33.2		5.5		
141		1.8		1.3		
1006	40.5					
38001		9.6			2.2	
38003		14.0	9.3			10.0
38023		3.6				
38037				1.2		
38038					3.6	
38039					10.0	
38048					6.4	
38064					2.4	4.2
38067					3.4	
38082						2.5
38087						2.2
Totals	40.5	62.2	9.3	8.0	28.0	18.9
Total	166.9 Lane Miles					

FIGURE 6 COUNTY SNOW REMOVAL PRIORITY MAP

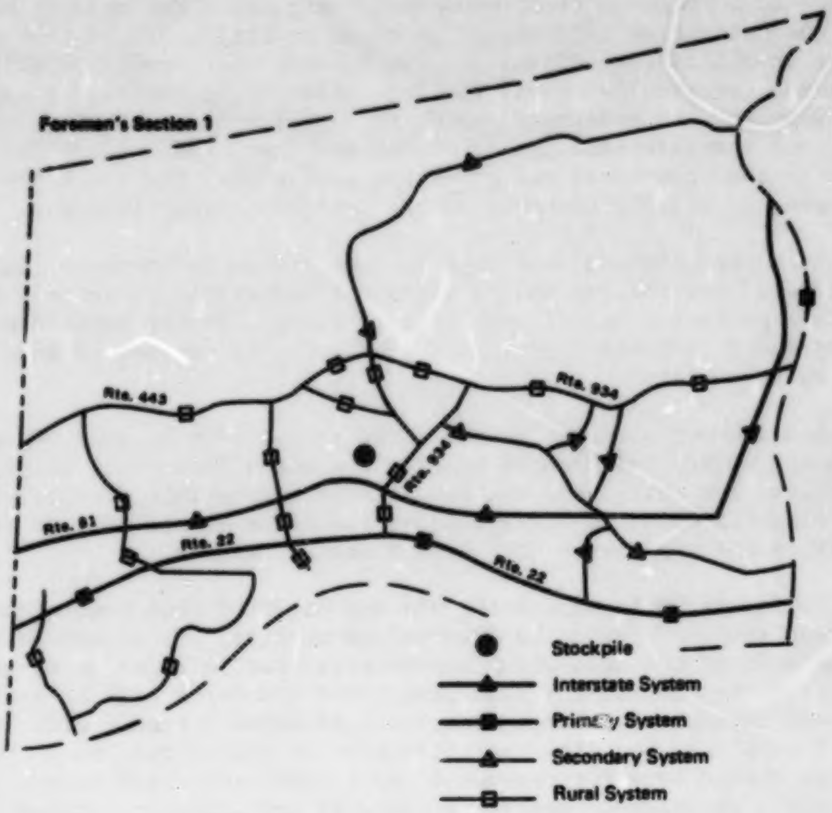
Within the foreman section, equipment assignments are made in accordance with the priorities established as shown in Figure 7. On this summary figure is all of the information the foreman will need, including stockpile locations, operator's names, the lane miles to be covered by each piece of equipment, the equipment number or rental agreement number, the equipment type, and the telephone number of the operator. Additional information includes the radio call number of the supervisor, the stockpile number and the name and telephone number of the assistant superintendent.

The third breakdown in this organization, shown in Figure 8, again shows the foreman section map and outlines the individual operator's route. This map is kept in the cab of each vehicle along with the calibration data for the spreader, and helps provide a continuity of service if road assignments have to be switched.

A work breakdown such as the one shown is based on a level of service for which the county maintenance manager has classified roads as primary, secondary, and rural, and has established appropriate service priorities. This classification is often made on the basis of the ADT, or sometimes simply on the experience of the maintenance manager.

Penn DOT's system is more elaborate and detailed than traditional methods of organization. But it has several advantages. It organizes in a common format much of the data which supervisors need in order to manage. It increases the probability that prescribed standards will be applied and followed throughout a large area; this promotes not only efficiency in use of supplies, but also the uniformity of winter road conditions which drivers should have for reasons of both convenience and safety. Personnel within the department, whether drivers or top managers, can be transferred from one job to another but still have guidance from common operating instructions applied to each county, section, and route. A related advantage, from both driver and managerial viewpoints, is that each truck driver knows what is expected of him by his supervisors in the very top of the chain of command, but the zone of discretion can be clearly limited and understood. This system also enables managers to pinpoint responsiblities, an important attribute of any organization. Moreover, it presents a mass of important data in compact yet clear form, which can aid managers in expanding both their strategy and their tactics to outside examiners, whether from other government agencies, the legislature, or the public. Finally, this clearly-presented system makes easier the inevitable process of change and adjustment.

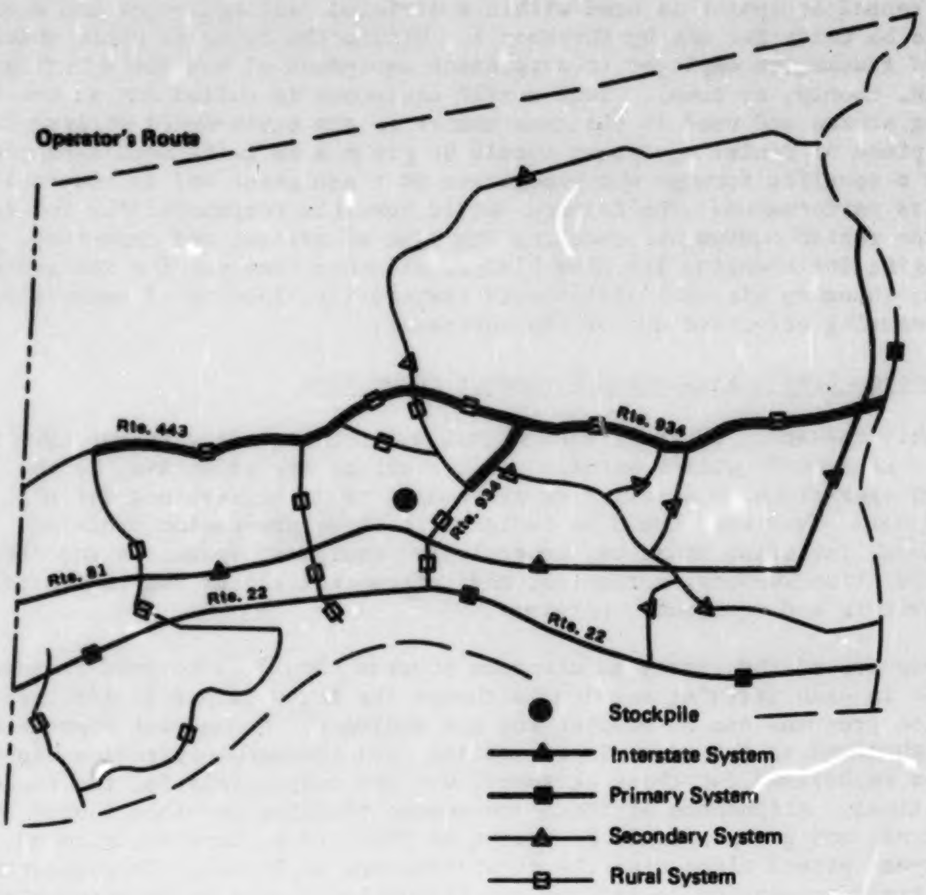
In this organization, the responsibility for maintaining roads is located at the foreman's level because he and his equipment operators are in the best position to judge the condition of the road, to see how the weather conditions are affecting the road surface, and to observe the traffic conditions. Almost all vehicles are equipped with two-way radios so that instant communication can be maintained with the section foreman. With this communication, the section foreman as he patrols his section, can be appraised of developing road conditions, of breakdowns, and of the progress in plowing or spreading of chemicals; he can reassign equipment in the event of breakdown or if level-of-service priorities have to be modified.


Foreman's Section 1
Rte. 443
Rte. 934
Rte. 934
Rte. 81
Rte. 22
Rte. 22
Stockpile
Interstate System
Primary System
Secondary System
Rural System

Key	Name	Lane Miles	Equipment No. or Agreement No.	Telephone No.	Type Eq.
●	P. Harrison	Stock Pile	178–1046	665–2049	L
▲	R. Kastler	40.5	377–6672	665–4489	G
▲	A. Catino	40.5	308–4089	665–3111	P/S
▲	J. Metzger	40.5	576–4066	665–3681	P/S
▲	K. Leonard	40.5	Rented Hopper	673–8139	S
■	B. Friksen	38.7	Rented	665–4746	G
■	L. Champey	38.7	274–4081	665–3478	P/S
□	G. Krassner	30.0	806--2066	665–3693	P/S
△	E. Coburn	27.4	866–4067	665–4565	P/S
□	T. McNulty	30.3	371–4067	665–2431	P/S

Foreman – T. O'Leary
Assistant Superintendent – P. Daniker

FIGURE 7 FOREMAN'S SECTION MAP


Operator's Route
Rte. 443
Rte. 934
Rte. 934
Rte. 81
Rte. 22
Rte. 22
Stockpile
Interstate System
Primary System
Secondary System
Rural System

Key	Name	Lane Miles	Equipment No. or Agreement No.	Telephone No.	Type Eq.
▬	G. Krassner	30.3	806–2066	665–3693	P/S

FIGURE 8 OPERATOR'S ROUTE MAP

When rented equipment is used within a division, all equipment and accessories should be ready for use by November 1. Within the terms of their contract, rented trucks are employed to supplement equipment of the jurisdictions (state, county, or town). Such rental equipment is called out as needed during storms and used in the same manner as any state-owned equipment. Each piece of rental equipment should be given a definite work assignment under a specific foreman who supervises that equipment and is responsible for its performance. The foreman should have the responsibility for calling out the rented equipment, checking its time of arrival and departure, arranging for changing its plow blades, allowing time out for the operator's meals, changing his work assignments temporarily, loading of materials, and ensuring effective use of the equipment.

Pre-Season Crew Training and Equipment Inspection

Probably the most important action that maintenance managers can take to ensure that their winter maintenance operations are effective, is to review operations in a series of pre-season training sessions for all personnel. Everyone should be included in these pre-season training sessions, including managers, supervisors, equipment operators and their helpers, time keepers, mechanics, and, of course, all of the contractor supervisors and equipment operators.

All aspects of the winter maintenance program should be covered to some degree in each training session, although the focus of particular training session programs can be adapted for the audience. Management aspects may be emphasized at the supervisors meeting, and equipment-operation aspects may be emphasized for those personnel who are responsible for the field operations. Attendance at these pre-season training sessions should be required, and groups should be chosen so that older, more experienced employees attend along with the first-time new employees. Throughout each training session, questions and discussion should be encouraged so that the operation is fully understood and improvements can be suggested.

The techniques that can be utilized in pre-season crew training include classroom instruction, shop demonstration, equipment dress rehersals, and finally route familiarization. All of these techniques should be used to some degree in each program and should be tailored to the particular need of the organization responsible for the winter maintenance program. The program can begin as early as September, depending upon when the winter season begins, and continue right up until the winter season begins. Although efforts should be made to complete the program before November 1, training should be considered as an on-going, ever-changing function, which can continue throughout the winter season as new information or techniques are brought to the attention of the winter maintenance organization.

Classroom Instruction

All training sessions should be tailored to small groups (five to ten participants at a time) so that the instruction can be personalized and questions and discussions encouraged. Instruction material should be prepared by the parent organization so that uniformity is guaranteed throughout the jurisdiction.

Some of the techniques that have been employed by various organizations, are listed below in descending order of preference:

- Seminars prepared and executed by the parent organization with slides and movies,
- Seminars conducted by local supervisors including slides with coordinated sound tracts or slides with a tape recorder,
- Slides with a text prepared by the parent organization, and
- Discussions of local operations and standard procedures.

Topics to be covered at these sessions include;

- Winter working hours and shift rotations;
- Mobilization;
- What to do and when to do it under varying weather conditions;
- Coordinating operations with weather changes, traffic conditions, and time of day;
- How to run a spreader;
- Quantities of chemicals and/or abrasives for varying weather conditions;
- Where to spread chemicals on the road;
- Calibration of spreaders; and
- Hazards to the environment.

Table-top demonstration models are useful for demonstrating plowing techniques. One town utilizes a model truck with plow to show employees how and how not to plow snow. The model operates on a street mock-up, which includes the difficult plowing situations that may arise including a cul-de-sac, and various types of intersections including multi-street, curbs, driveways, and straight road sections. Dry sand or soap powder simulates the snow. Each person is given a chance to "drive" the plow truck.

Shop Demonstration

Another effective tool in the training session is the shop demonstration during which pre-snowfall instruction can be given on spreader operation, plow maintenance and hook up, and spreader calibration. In these shop demonstrations, an instructor (in this case an experienced operator) can demonstrate to each new operator how to mount a plow and properly adjust it for the various weather conditions and how to prepare a spreader for the different materials and rates of application that are expected in the winter operation program. Under supervision, each new operator must perform these functions on the specific piece of equipment which he will be responsible for using during the winter season.

These shop demonstrations should also include the calibration of a spreader. For details of spreader calibration see Chapter VI.

Equipment Dress Rehearsal

Following procedures used by the Minnesota and Michigan Highway Departments, all equipment in a section should be mobilized on one day for a formal equipment inspection and dress rehearsal. In order to stress the importance of this inspection, managers at all levels must be involved. These inspections are usually conducted by personnel from the head maintenance office.

The purpose of this inspection is to determine if the equipment is in proper mechanical condition for the coming winter season. A detailed and complete inspection is made of each piece of equipment. All accessories are checked thoroughly, and the general condition of the equipment is noted on the Equipment Pre-Season Checklist shown in Figure 9. Minor repairs are made, and major work is scheduled for a later date by the shop foremen.

Route Familiarization

The last step in the training program should enable the operator and his helper or wing-plow man to become thoroughly familiar with the section or sections or road over which he is to operate. Frequent stops should be made to inspect obstacles such as guard rails, manhole covers, and curb stones, which may cause damage to equipment if struck. High stakes with reflectors or perhaps just a tall branch should be attached to these obstructions so that the operator can identify them under the adverse weather conditions experienced during storms. Remember, the obstacle that is visible when the leaves are beginning to fall will probably be invisible or extremely difficult to spot from a plow or spreader when the weather conditions are poor.

Where to Get Additional Information

Several organizations have devoted considerable thought and efforts to develop effective training programs for winter maintenance personnel. They are aware of both the operational and the environmental problems and, through these programs, have addressed the issues.

The Salt Institute has produced an effective program entitled "Sensible Salting" that can be incorporated into a pre-season crew training program. Sensible Salting programs are conducted by skilled personnel from the Salt Institute and include the following:

ENGINE COMPARTMENT

Oil leaks - valve covers, oil pan, filter housing, lines, etc. ( )

Oil level and condition ( )

Power steering pump - belt, condition & adjustment, fluid level ( )

Cooling system

- Coolant level ( )
- Coolant specific gravity protected to -___°F ( )
- Radiator condition - leaks ( )
- Radiator hoses condition - leaks ( )
- Heater hoses condition - leaks ( )
- Fan belt - condition & adjustment ( )
- Fan blade - looseness, cracks ( )
- Water pump - seal, bearings ( )
- Radiator shutters - condition & operation ( )

Electrical system

- Battery - holder, hold downs, caps missing ( )
- Battery cables - tightness, corrosion ( )
  1 2 3 4 5 6
- Electrolyte level ( ) ( ) ( ) ( ) ( ) ( )
- Electrolyte specific gravity [ ][ ][ ][ ][ ][ ]
- High rate discharge test - battery amp/hr rating
  - Time discharged ( )
  - Amperes ( )
  - Minutes ( )
  - Final voltage ( )
- Alternator
  - Belt - condition & adjustment ( )
  - Lubrication (if necessary) ( )
  - Wiring - condition & tightness ( )
  - Voltage regulator - mounting, wiring ( )

Brake system components

- Hydraulic
  - Master cylinder - condition, fluid level ( )
  - Lines - leaks & condition ( )
- Air
  - Compressor - lubrication, air & cooling lines tight ( )
    - Belt - condition & adjustment ( )
  - Intake filter - condition & clean ( )

FIGURE 9 PRESEASON EQUIPMENT CHECKLIST

Fuel system (gas)

- Carburetor - mounting, leaks, etc. ( )
  - Air cleaner - condition, ducts ( )
- Fuel pump - tightness, leaks ( )
- Fuel filter - drain water, clean or replace element ( )

Fuel system (diesel)

- Air cleaner - condition & service ( )
- Transfer pump - condition & leaks ( )
- Injection pump - condition & leaks ( )
- Injectors - condition & leaks ( )
- Filters - condition & service ( )

Ignition systems

- Coil - condition & clean ( )
- Distributor
  - Cap - condition & clean ( )
  - Rotor - condition & clean ( )
  - Points & condenser - condition & adjustment ( )
- Primary wiring - condition & tightness ( )
- High tension wires - condition & tightness ( )

Clutch master cylinder - condition, fluid level ( )

Windshield washer tank - fill ( )

Front mounted hydraulic pump - condition & leaks ( )
- Clutch - operation & adjustment ( )

Steering box - fluid level check ( )

With engine running

- Engine governor settings ( )
- Air pressure governor settings ( )
- Voltage regulator settings ( )
- Engine timing settings ( )

CHASSIS INSPECTION

Steering

- Wheel bearings - condition, adjustment & lubrication ( )
- Steering box - seals, bearings, adjustment ( )
- Drag link - tightness, lubrication ( )
- Bell crank - tightness, lubrication ( )
- Tie rod - tightness, lubrication ( )
- Steering arms - bent, tightness ( )

FIGURE 9 CONTINUED

- Power steering cylinder - condition & tightness ( )
- Alignment
    - Toe in ( )
    - Caster ( )
    - Camber ( )
    - Travel stops ( )

Brakes

- Air

	Front		Rear			
			Front Bogie		Rear Bogie	
	R	L	R	L	R	L
• Actuators	( )	( )	( )	( )	( )	( )
• Lines	( )	( )	( )	( )	( )	( )
• Hoses	( )	( )	( )	( )	( )	( )
• Adjustors	( )	( )	( )	( )	( )	( )
• Quick release valves	( )		( )		( )	

    - Air reservoir - leaks, relief valves, lines ( )
    - Safety reservoir - leaks, relief valves, operation ( )
- Hydraulic
    - Booster - leaks, operation ( )

	Front		Rear			
			Front Bogie		Rear Bogie	
	R	L	R	L	R	L
• Hoses	( )	( )	( )	( )	( )	( )
• Lines	( )	( )	( )	( )	( )	( )

- Parking brake - operation & adjustment ( )

Springs

	Front		Rear			
			Main		Auxiliary	
	R	L	R	L	R	L
• Mounts, clamps, pins	( )	( )	( )	( )	( )	( )
• Springs	( )	( )	( )	( )	( )	( )
• U-bolts	( )	( )	( )	( )	( )	( )

Truck frame - bent, cracks, loose ( )

- Plow frame - loose, bent, cracks, elongated bolt holes ( )
- Wing plow frame - loose, bent, cracks, elongated bolt holes ( )
- Underbody scraper
  frame - loose, bent, cracks, elongated bolt holes ( )

Clutch - condition & adjustment ( )

Transmission(s) mounting - leaks, lubrication level ( )

Drive shaft(s) U-joints - carrier bearings, lubrication ( )

FIGURE 9 CONTINUED

Exhaust system - mounting, corrosion ( )

Fuel tank(s) - mounting, lines, gauges, caps, leaks ( )

Hydraulic oil reservoir - mounting, lines, gauges, caps, leaks ( )

Rear end(s) & power divider (if used) - mounting, lubrication level ( )

Miscellaneous component mounting (hydraulic pumps, P.T.O., etc.) ( )

- Condition - mounting, operation ( )

Tires & wheels - check tread, sidewalls, inflation, wheels bent, cracked, lug nuts tight ( )

- Tires

			Rear							
			Front Bogie				Rear Bogie			
	Front		R		L		R		L	
	R	L	In	Out	In	Out	In	Out	In	Out
• Condition	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
• Inflation	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
• Wheels	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
• Lug nuts	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

Dump body - condition & operation ( )

- Tail gate - condition & operation ( )

Spreader - general condition, controls, operation ( )

- Auxiliary engine (if used) ( )
- Flight conveyor - chain, bars, shafts, sprockets, etc. ( )
- Spinner - condition, operation ( )
- Baffles - gate, top screen, condition & operation ( )
- Hydraulic motors & lines - condition & leaks ( )
- Lubrication - gear reduction, shafts, sprockets, etc. ( )

Front plow

- A-frame - bent, broken ( )
- Lift piston - mounting, lines, leaks ( )
- Swing pistons - mounting, lines, leaks ( )
- Trip mechanism - condition & operation ( )
- Cutting edge - worn, bent, broken ( )

Wing plow - general condition ( )

- Hoist mechanism - condition & operation ( )
- Swing mechanism - condition & operation ( )

FIGURE 9 CONTINUED

Underbody scraper - mounting, bent, cracks ( )

- **Lift mechanism** ( )
- **Trip mechanism** ( )
- **Cutting edge** ( )

CAB CHECK

General condition of body, fenders, hood, grill, running boards, etc. ( )

- **Glass - windshield, side & vent windows, rear window** ( )
- **Doors - latch, handles, condition & operation** ( )
- **Seats - upholstery, adjustment** ( )
- **Floorboards - padding trim** ( )

Heater & defroster - condition, output, leaks ( )

- **Fan switch** ( )
- **Cable controls** ( )
- **Hoses & ducts** ( )
- **Auxiliary fan defroster** ( )

Switches & lights - condition & operation

	High		Low	
	R	L	R	L
• **Headlight & dimmer switch**	( )	( )	( )	( )

	Front		Rear		
	R	L	R	L	
• **Turn signals**	( )	( )	( )	( )	
• **Tail lights**			( )	( )	
• **Brake lights**			( )	( )	
• **Parking lights**	( )	( )			
• **Cab markers**					( )
• **Clearance lights**	( )	( )	( )	( )	
• **Plow & sander lights**					( )
• **Rotating beacon**					( )
• **Spotlight**					( )
• **Interior cab light**					( )
• **Map light**					( )
• **Courtesy light**					( )

Instruments

- **Speedometer** ( )
- **Tachometer** ( )
- **Ammeter** ( )
- **Temperature gauge** ( )
- **Fuel gauge(s)** ( )
- **Oil pressure gauge** ( )

FIGURE 9 CONTINUED

- Air pressure gauge ( )
- Low air-pressure warning buzzer ( )
- Miscellaneous gauges ( )

Driving controls

- Steering wheel - condition & operation ( )
- Clutch pedal - operation & adjustment ( )
- Brake pedal - operation & adjustment ( )
- Accelerator pedal - operation & adjustment ( )
- Transmission lever(s) - 2-speed button, operation ( )
- Parking brake - operation & adjustment ( )
- Horn - operation ( )
- Windshield wipers - operation ( )

2-way radio - check all frequencies, operation & interference ( )

Plow controls

	Raise	Lower	Float	Swing
• Front plow	( )	( )	( )	( ) ( )
• Wing plows	( )	( )	( )	( ) ( )
• Underbody plow	( )	( )	( )	( ) ( )

Spreader controls

- Ground-speed controller ( )
    - Calibration check ( )
    - Operation - all ranges ( )
    - Manual override ( )
- Manual operation ( )
    - Calibration check ( )
    - Conveyor control - operation, repeatability ( )
    - Spinner control - operation, repeatability ( )

Emergency & safety equipment

- First aid kit ( )
- Fire extinguisher ( )
- 4-6 fuses ( )
- Reflector flares ( )
- Shovel ( )
- Tire chains ( )
- Tow chain cable ( )
- Red flags ( )
- Wing push bar ( )
- Wing push bar shear pins ( )
- Flashlight ( )
- Light kit ( )
- Wheel chocks ( )

FIGURE 9 CONTINUED

- A movie on snow and ice control operations,
- A movie on calibration techniques,
- Discussions concerning snow and ice control operations,
- Demonstrations of the calibration of a spreader (usually performed on a spreader belonging to the host organization), and
- Additional information to be supplied by the Salt Institute

The New England Chapter of the American Public Works Association has developed a training film designed to improve snow plowing operations. The film is about a snow school designed to help eliminate the common mistakes in snow plowing and combines classroom demonstration with a model snow plow and a table-top model of common street plowing situations and actual street plowing scenes combined with descriptions of good plowing techniques.

The Michigan Department of State Highways has developed two internal training programs for snow and ice control. One program concerns how much salt to use and where to put the salt when spreading it. The other program concerns calibration of spreaders and is based principally upon Salt Institute's Sensible Salting Program.

MOBILIZATION

As it becomes increasingly clear that bad weather is on the way, warning must be given so that men and equipment can be ready. The warning procedures in Chapter III indicate how supervisors or their designated alternates can be directly notified by phone that snow and ice control actions will probably have to be initiated. Acknowledgement of this notification is usually required and is logged by the weather warning personnel.

Each road section must be provided with at least 3, and preferably 4 hours of warning along with a description of the magnitude of the storm so that crews can be alerted and materials and equipment can be prepared for the particular weather expected. The exact time for mobilization is, of course, the responsibility of the road section supervisor.

Thus, the most important warning is the first or preliminary warning that bad weather is on the way. At this time, the supervisor makes his decision about what to do and when to do it based on past experience with similar warning. For instance, he may elect to apply chemicals or abrasives and/or wait for snow to accumulate and then plow.

The degree of mobilization will probably depend upon the magnitude of the storm. For a large, full-scale storm, the entire road section crew may be mobilized including truck spreader operators, front-end loader operators, wing plowmen, laborers, foremen, and mechanics. For a small storm or one that begins at night, just the spreader operators may be required, and they will load their own trucks.

ISSUING OF ORDERS

The road section supervisor has responsibility for issuing orders concerning both mobilization of manpower and equipment and the application rate for deicing material. He is responsible for interpretation of the weather reports and the road conditions at hand, prescription of the application rate for deicing chemicals or abrasives, and the initiation of plowing operations. These orders are usually issued verbally to the foremen and then in turn to the equipment operators who adjust their spreaders for the amount prescribed and attach the requisite plows as needed.

APPLICATION RATE FOR DEICING MATERIAL

The amount of deicing material that must be applied to improve the driving conditions on a particular section of highway at any specific time during a given storm is dependent primarily on the weather, the traffic conditions, and the level of service to be maintained. From an environmental point of view, the minimum amount to be applied would be no chemicals--clearly not an acceptable alternative except perhaps on little-used rural roads. From the point of view of improved driving conditions, an amount equal to or slightly in excess of a not-yet-determined minimum should be used. Unfortunately, no generally accepted guidelines have been established for minimum amounts of chemical to be applied for different weather and traffic conditions. Furthermore, no experimental programs have been conducted to determine the minimum amount of chemicals required--a condition that has been long recognized by many maintenance managers.

Those guidelines that are presently being used have evolved from the point of view of improving the driving conditions. Until there is widespread concern for the environment on the part of the driving public (see Part Five of this manual) or until the demand for bare roads at all times is diminished, these guidelines will not change significantly. In addition, since existing guidelines have not been verified experimentally, they have simply been found to be adequate.

The critical environmental issue is not the exact amount of chemical material that is prescribed for a given set of weather, traffic, and road capacity conditions, but rather that no more than the recommended prescribed amount be used (a matter of equipment calibration) and that a minimal number of applications be made during each storm (a matter of weather prediction and supervision of the operation).

A major finding of the study leading up to the writing of this manual was that many agencies did not know how much salt or deicing chemical was being spread with each application and, in most instances, the amount was not only greater than expected but also greater than the amount prescribed. This startling fact was revealed in many agencies when, for either financial or ecological reasons, a concerted effort reduced the use of chemicals yet did not reduce the level of service or the driving conditions.

General Guidelines

In view of all of these limitations, suggested guidelines for chemical application rates are given in Table 3. These guidelines reflect the lower limits of chemical usage in current practice among a wide range of city, town, county, state, and toll-road authorities. Five classifications of roads comprise the basic parameters. The guidelines are presented in terms of the amount of material that is to be spread upon a mile of two-lane road or per mile of two lanes of a divided highway. How this material is to be spread on the highway must be determined by each agency.

Generally, chemicals such as salt (sodium chloride) and/or premixes of salt and calcium chloride are spread in a narrow pattern in the center of two-lane roads or on the crown of multi-lane divided highways. On super elevated curves, the material should be placed as high as possible on the curve so that the brine produced will flow across the road surface. Under some conditions a full width pattern is required particularly on heavily traveled roads where all lanes carry equal traffic.

In some agencies, particularly on secondary roads, the material is not spread but simply placed in a windrow right on the centerline of the highway where the melting action produces brine which will flow in both directions across the road. In the case of abrasives, a larger spread pattern is generally used in order to obtain good coverage of both driving lanes either on a two-lane road or on a multi-lane highway. Care must be exercised during spreading to ensure that material is not spread into the breakdown lanes or onto the shoulders where it is not effective.

The New York State Department of Transportation has developed guidelines for spreading of deicing chemicals that call for an initial application of material at the beginning of storms followed by applications at a lower rate on an as-needed basis. The initial application forms a brine on the road surface which prevents bonding of snow and ice and the subsequent buildup into snow pack. The smaller applications, particularly when made immediately after plowing (often by the plow trucks itself), maintain this film of brine at the road surface. The last small application is made when the storm is almost finished and is beneficial in drying the road particularly if a temperature drop occurs at storm's end.

The quantities prescribed in Table 3 are for two-lane roads; when single lanes are being treated, such as exit ramps and acceleration lanes, the rates should be half of those stated in Table 3. Reducing this rate should be the duty of the spreader operator or his assistant and is an important environmental consideration, particularly for large cloverleaves at the junction of multi-lane highways where there is a large, concentrated usage of deicing chemicals.

Table 3 GUIDELINES FOR CHEMICAL APPLICATION RATES

WEATHER CONDITIONS			APPLICATION RATE (Pounds of material per mile of 2-lane road or 2-lanes of divided)			
Temperature	Pavement Conditions	Precipitation	Low-and High-Speed Multilane Divided	Two and Three-Lane Primary	Two-Lane Secondary	INSTRUCTIONS
30°F and above	Wet	Snow	300 salt	300 salt	300 salt	- wait at least 0.5 hour before plowing
		Sleet or Freezing Rain	200 salt	200 salt	200 salt	- reapply as necessary
25-30°F	Wet	Snow or Sleet	initial at 400 salt repeat at 200 salt	initial at 400 salt repeat at 200 salt	initial at 400 salt repeat at 200 salt	- wait at least 0.5 hour before plowing; repeat
		Freezing Rain	initial at 300 salt repeat at 200 salt	initial at 300 salt repeat at 200 salt	initial at 300 salt repeat at 200 salt	- repeat as necessary
20-25°F	Wet	Snow or Sleet	initial at 500 salt repeat at 250 salt	initial at 500 salt repeat at 250 salt	1200 of 5:1 Sand/Salt; repeat same	- wait about 0.75 hour before plowing; repeat
		Freezing Rain	initial at 400 salt repeat at 300 salt	initial at 400 salt repeat at 300 salt		- repeat as necessary
15-20°F	Dry	Dry Snow	plow	plow	plow	- treat hazardous areas with 1200 of 20:1 Sand/Salt
	Wet	Wet Snow or Sleet	500 of 3:1 Salt/ Calcium Chloride	500 of 3:1 Salt/ Calcium Chloride	1200 of 5:1 Sand	- wait about one hour before plowing; continue plowing until storm ends; then repeat application
below 15°F	Dry	Dry Snow	plow	plow	plow	- treat hazardous area with 1200 of 20:1 Sand/Salt

Included in Table 3 are the timing of applications and suggested waiting periods between chemical application and the initiation of plowing. This waiting period is critical from the points of view of operations, improved driving conditions, and the environment because it allows the deicing chemical to form a brine, spread out on the highway, prevent bonding of precipitation (snow, sleet, or freezing rain) and to be dissolved completely in this process before plowing occurs. Premature plowing will pick up the material in undissolved form and deposit it on the shoulder where it is of no use in improving the driving conditions. In short, when deicing chemicals are used, the philosophy should be to use them fully and not throw them away.

Oftentime highway men are confronted with a problem of changing weather conditions. This emphasizes the need for close monitoring of the weather and judging what the weather will do on the basis of past experience with similar storms. This is where the skill of maintenance managers is crucially important. When changes in weather conditions are predicted, the supervisor should take these changes into account when prescribing the material and quantities. For instance, if there is a high probability of rising temperature, the amount of material prescribed should be reduced in anticipation of the temperature rise. Likewise, if the temperature is predicted to drop rapidly at the end of a storm, it is important to get a final application of salt down so that the road will dry up as the storm ends and so that icy patches cannot form.

Environmentally Critical Areas

Some agencies are consciously reducing the amount of material that is used in environmentally critical areas, such as watersheds used for water supply. Several courses of action are open in these areas.

First of all, the level of service of roads in these areas can be lowered, particularly on primary and secondary roads. Care should be taken to notify motorists that there will be a reduction of the level of service in these areas.

Next, the amount of salt used can be reduced by application of smaller amounts and less frequently. Some jurisdictions are reducing the amount of sodium that enters such environmentally critical areas by using mixtures of salt and calcium chloride in ratios of 3:1 or 5:1 salt to calcium chloride.

Prewetting of the salt has been used in order to accelerate the action of salt, and at the same time to utilize less total material. These salt prewetting schemes usually use materials that do not freeze at extremely low temperatures, such as solutions of salt, calcium chloride, methyl alcohol, or propylene glycol.

The North Dakota Highway Department has successfully prewetted salt with water alone sprayed on top of the loaded truck at a rate of 18-20 gallons per cubic yard of salt. Salt brine pumped from an area drainage catchment basin can also be used for prewetting salt. Care must be exercised when using water or dilute solutions in sub-freezing weather to keep water hoses and pumps from freezing. A prewetted load of salt must not remain in the truck for a prolonged period during sub-freezing weather because it will freeze.

The prewetting material of choice by some agencies is a 32% (by weight) solution of calcium chloride (4.12 lbs of 94-97% CaCl in 1.0 gal of water, or 5.79 lbs of 77-80% $CaCl_2$ in 1.0 gal of water). Several techniques are used for applying it to the salt. In some jurisdictions, calcium chloride solution is pumped onto the dry load of salt before the truck driver proceeds along his route. In Iowa, Michigan, New York, and others, a tank of calcium chloride solution is carried on the truck, and the calcium chloride solution is dispensed into the discharge chute of the spreader either by means of a pump or under gravity. The object is to coat thoroughly each particle of salt with calcium chloride solution before it is applied to the snow or ice on the road; this can initiate immediate melting of the snow or ice to form additional brine that dissolves the crystals of salt. Prewetting keeps the salt from bouncing off the roadway during spreading and from blowing away once it is on the road. A typical application rate for prewetting of salt as it is dispensed at the back end of a spreader is at 8 gal per ton. For calcium chloride solutions applied beforehand to a full load of salt in the truck, a typical application rate is 10 gal per ton, and the material is pumped onto the top of the load just before the truck leaves the yard.

Connecticut's Bureau of Highways has been experimenting in 21 critical watershed areas with several mixtures of sand, salt, calcium chloride, and 50/50 mixture of propylene glycol to accelerate the action of the salt and calcium chloride. The three mixtures being used are summarized in Table 4. Mixture One containing no sand, is used on the interstate highways where they pass through these watersheds. The standard Connecticut premix (3:1 salt/calcium chloride) is spread at a rate of about 430 lb per two-lane mile and is prewetted with a 50-50 mixture of propylene glycol and water at a rate of 10 gal per two-lane mile. Mixture Two uses 11 parts sand and two parts of standard premix. This mixture is prewetted with 10 gal per mile of 50-50 propylene glycol water mixture. Of the three mixtures being used Mixture Two, as noted in Table 4, contains the smallest amount of salt and calcium chloride. Mixture Three is made from seven parts sand and two parts of standard premix. No propylene glycol is used for prewetting of this mixture.

Additional Techniques for Minimizing Chemical Applications

In one way or another, all of the techniques outlined in this manual are directed toward minimizing the amount of deicing chemicals and/or maximizing the effect of those chemicals that are used. As many of these techniques should be incorporated as possible, appropriate, and economically feasible.

During each winter storm, the optimum chemcical application rate is a combination of many factors including the level of service, weather conditions changing with time, the state and characteristics of the chemicals used, the time of application relative to both changing traffic and weather

Table 4 MIXTURES FOR ENVIRONMENTALLY CRITICAL AREAS

	Mixture 1	Mixture 2	Mixture 3
Spread Rate (lbs/mile of 2-lane road)	430	1500	1500
Description of Mixture Dry Ingredients	all 3:1 Premix	11 parts sand 2 parts 3:1 Premix	7 parts sand 2 parts 3:1 Premix
Amount of 50/50 propylene glycol	10	12	none
Calculated Quantities (lbs/mile of 2-lane road)			
• salt	320	180	260
• calcium chloride	110	45	86
• sand	---	1275	1154

3:1 Premix = 3 parts Rock Salt and 1 part Hydrated Calcium Chloride by weight

Courtesy of State of Connecticut Department of Transportation conditions, and the topography and type of road surface. The actual determination of an application rate by a maintenance manager is a matter of his best judgment. Usually the rate is chosen that will reasonably cover as many of the uncontrollable variables as possible.

Many noteworthy techniques have been developed by maintenance managers who are attempting to minimize the application rates for deicing chemicals and abrasives, and/or to maximize the deicing effect of those materials applied. In the following listing, are some additional techniques that were noted during the course of the study preceding the writing of this manual.

- Application of chemicals should occur in smaller increments in response to changing traffic and weather conditions. Although this requires more attention by operators, foremen, and other maintenance managers and much more intensive use of equipment, the techniques guards against the possibility of unnecessary over-application of environmentally harmful chemicals.

- Abrasives should be used with little or no use of chemicals in locations where traffic is not heavy enough to remove them rapidly from the road. A mixture of 20 parts of sand and one part salt (the minimum amount required to keep a sand pile from freezing) often results in sufficient melting action to provide an adequate level of service on secondary roads and roads in residential areas.

- For storms that are expected to produce heavy snowfalls, application of salt at the onset of the storm followed by early and continued plowing throughout the storm will provide an adequate level of service, particularly if it is followed by a light application of salt at the end of a storm in order to clear up the road and prevent freezing when the temperature drops.

- Less chemicals are required to prevent snow pack from forming if underbody scrapers are used extensively in the plowing program. These scrapers can clear the road surface of hard-packed snow more readily than a conventional front-mounted plow.

- Through coordination of the timing of plowing and chemical applications, the salt is allowed to melt, form brine, and break the snow-ice bond at the road surface before snow is plowed off. Success of this technique requires keen observation of conditions and good communication among crew foremen and district supervisors.

- When roads are subject to regular one-way commuter traffic, both plowing and chemical applications should be concentrated on in-bound or out-bound lanes as appropriate to the peak traffic load and time of day.

- A towed spreader (see Figure 25 in Chapter V) is useful for applying concentrated and controlled amounts of chemicals to areas on the roadway (such as the passing lane) that may need additional applications in such a well-defined area that a large spreader truck would put too much material out over a too large area.

PRECAUTIONS IN HANDLING OF DEICING CHEMICALS

Once the application rate has been prescribed, the action shifts from the supervisors or managers to the men who must carefully use these deicing chemicals. A complete description of precautions concerning handling of deicing chemicals before application is given in Part III of Manual for Deicing Chemicals: Storage and Handling (EPA-670/2-74-033).[1] When the spreader trucks are being loaded before and during a storm good practices should be followed. In general, five precautions should be observed.

- If possible, load trucks or spreaders inside the salt storage shed. This reduces spillage and cleanup problems.

- Before the spreader truck leaves the shed or the loading area, clean it off--catwalks, top edges and ledges of the body, tanks, roof and fenders. This will keep the salt from spilling off where it is not wanted.

- Keep the loading area clean by immediately cleaning up any salt lying on the loading pad, and get it back under cover.

- Keep the salt dry by keeping it under cover as long as possible before loading it onto the trucks.

- Handle the salt as little as possible. Excessive handling causes large particles to break down into finer particles which reduces their effectiveness for clearing snow.

ROLE OF THE SPREADER OPERATOR

The spreader truck operator has the ultimate control over the amount of chemical that is spread on highways. The success of any program to minimize the amount of chemicals spread on highways is totally dependent on his enthusiastic acceptance of this goal. Thus, it becomes increasingly important that spreader operators be thoroughly familiar with the equipment and the desires of the foremen, supervisors, and other high officials responsible for the snow and ice control program.

Further, because he is out in the storm, the spreader operator is in the best position to judge the condition of his section of the road and the efficacy of his snow and ice control efforts, and can feed this information back to his foreman and supervisors. Maintenance of two-way radio communication with each spreader operator is as important as use of a well-calibrated, easily controlled salt spreader.

Control of the actual amount of salt spread should be in the hands of the spreader operator. He should be told by his supervisor the standard amount of salt that is to be spread on his particular run. The actual spreading rate may vary from place to place throughout the run depending upon the number of intersections, grades, and bridge decks that are subject to icing before the main road. However, as weather conditions change for better or for worse, the operator should have the option of increasing or decreasing his amounts within some limit, for instance +20 or -100 lb depending upon the weather and traffic he encounters. Before increasing the spreading amounts above this upper discretionary limit, the operator should seek guidance from his supervisor via the two-way radio. Clearly, to vary the spreading rate this way during a run requires equipment with in-cab controls which are in good operating condition.

All spreader operators should be trained to spread chemicals on the crown of the road or on the high side of the road and should know how to change spreading techniques or pattern in response to crosswinds that blow the material before it settles on the highway pavement. Further, he should know when to cease spreading chemicals and initiate a plowing operation.

Before beginning each snow control operation, the spreader operator should check out his truck thoroughly. This should be done before the spreader is loaded with chemicals. A good time to perform this inspection is when the driver is first called out or when he is called upon to attach his plow in readiness for a storm condition. Each driver should perform a preoperation walk-around inspection, checking all of the items listed in Figure 10. Upon completion of this check out, the operator can proceed to load the spreader with the assurance that his truck and spreader are in top operating condition.

ACCOUNTING FOR CHEMICAL USAGE

While careful control of the amount of deicing chemical that is spread is the primary means for minimizing the impact on the environment, a second major technique for control is the development of an accounting procedure that allows supervisors to keep track of the use of chemicals and to analyze the results obtained therefrom. The basic requirement for accounting for salt usage is knowing:

- what snow and ice control techniques were used,
- the type and amount of chemical used,
- where it was used and the number of lane miles covered,

UNDER HOOD

- Lube Oil ( )
- Coolant ( )
- Power-steering
  - pump reservoir ( )
- Alcohol injector ( )
- Windshield washer fluid ( )
- General:
  - Belts ( )
  - Leaks ( )
  - Loose components ( )

WALK AROUND

- Any fluid leaks under truck ( )
- Any damage or loosening of mounting bolts, etc. ( )
- Turn on lights
  - headlights ( )
  - clearance lights ( )
  - tail and stop lights ( )
  - flasher beacon ( )
  - plow and spreader lights ( )
- Turn off all lights
- Springs ( )
- Hangers ( )
- Pins and U-bolts ( )
- Wheel lug nuts ( )
- Tire inflation ( )
- Any stones between duals ( )
- Plow
  - trip mechanism ( )
  - mounting ( )
  - cutting edge ( )
- Spreader
  - any broken or loose components ( )
  - leaks ( )
  - hydraulic leaks ( )
  - deflector
- Hydraulic oil tank
  - mounting ( )
  - fluid ( )
- Air tank drain valve closed ( )

CAB

- Start engine
  - oil pressure ( ) fuel ( ) ammeter ( )
  - air pressure buildup time ( )
  - any abnormal engine or transmission noises ( )
  - all cab controls ( )
  - odometer ( )
  - speedometer ( )
  - tachometer ( )
  - brake ( )
  - hand brake ( )
  - radio operation ( )
  - calibration chart handy ( )
  - supply of Operator's Daily Trip Reports ( )
  - pencils ( )

FIGURE 10 PRE-OPERATIONS WALK-AROUND INSPECTION

- what the weather and road conditions were, and
- what the results were.

Three major classes of winter reporting are required in a successful management program for snow and ice control.

- the operator's daily storm report,
- the road section, supervisors storm summary report, and
- the road district's annual winter activity report.

Operator's Daily Storm Report

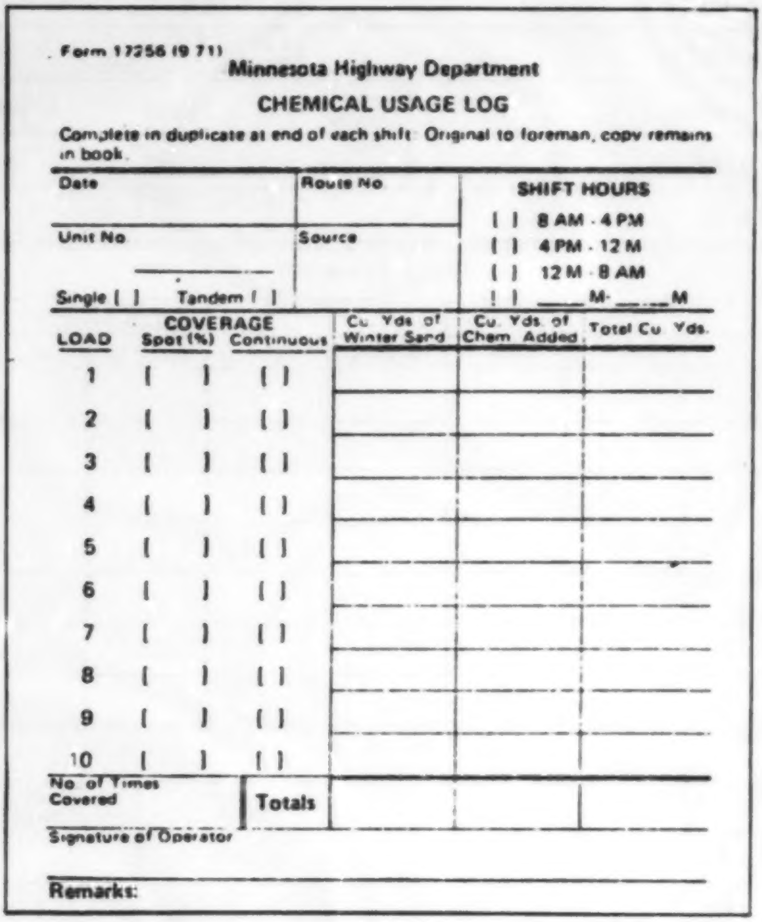
The starting point and probably the most important input to this management control procedure is the basic data provided by a daily truck operator's report. This report of winter activities, like any report to be completed by an operator, must be easily filled out (and accurately), yet contain sufficient information for meaningful analysis. Two operator reporting forms that incorporate much needed information are shown in Figure 11 and 12. A suggested model for an operator's daily report is shown in Figure 13.

Operator's daily reports should be hand-sized forms which can fit into a shirt or coat pocket and which are printed on heavy weight, high grade paper stock suitable for field usage even under damp conditions. Each operator is responsible for filling in the report card as material is loaded onto his truck and as work is accomplished. At the end of each shift, the operator totals up his usage of material and the lane miles on which the material was spread, and submits the card to his supervisor for verification. A supply of these operator activity cards should be kept in each truck. These operator reports can be used for accounting for materials usage for purposes of resupply and restocking and by the supervisor in preparing his storm summary report.

Supervisor's Storm Summary Report

The second important report in the management control of chemical deicing compounds is the road section supervisor's storm summary report. This report can be compiled from all of the daily reports by operators covering the period of a storm and with some additional data concerning the weather, which must be gathered by the supervisor. Six important parameters should be included in the supervisor's storm summary report.

- Total materials used;
- Number of applications;
- Total lane miles;



Form 17256 (9 71)

Minnesota Highway Department

CHEMICAL USAGE LOG

Complete in duplicate at end of each shift. Original to foreman, copy remains in book.

Date

Route No

Unit No

Source

Single [ ] Tandem [ ]

SHIFT HOURS

[ ] 8 AM - 4 PM
[ ] 4 PM - 12 M
[ ] 12 M - 8 AM
[ ] ____ M- ____ M

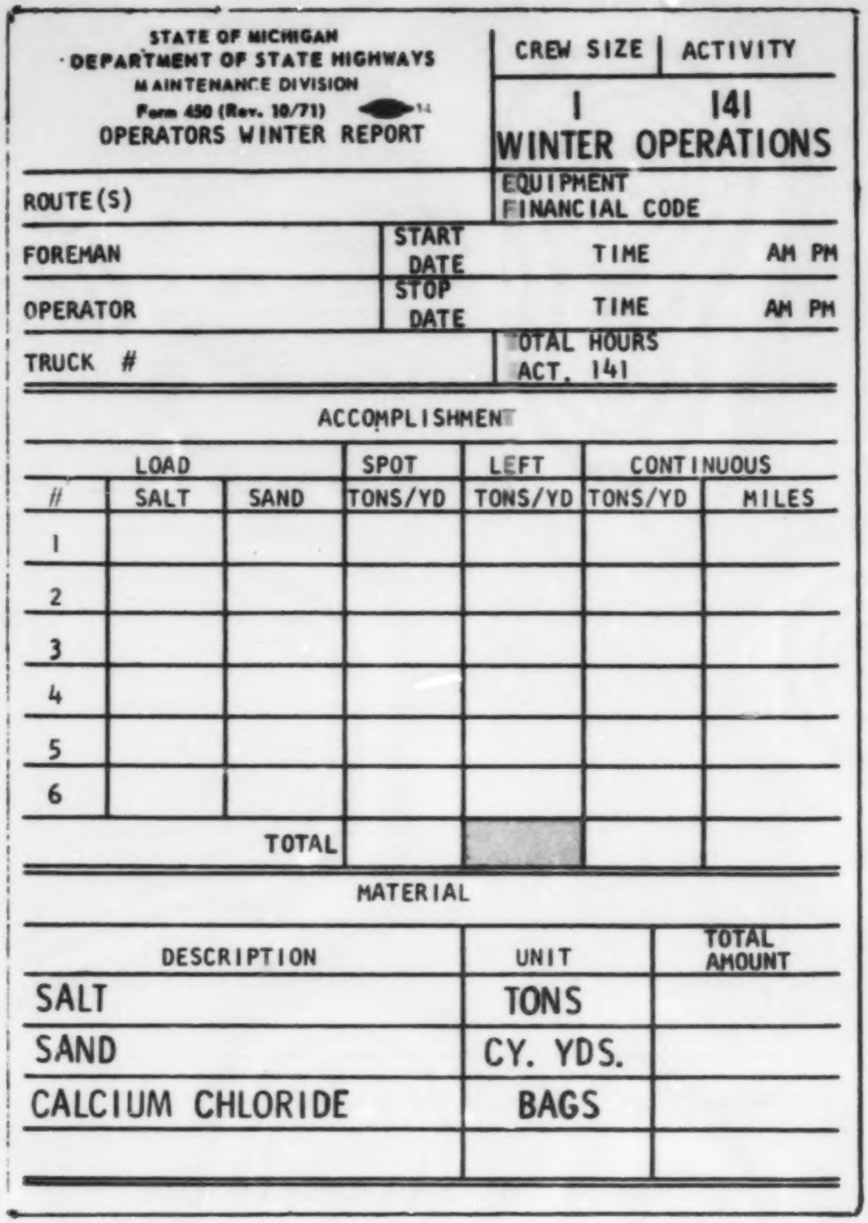
LOAD	COVERAGE Spot (%)	COVERAGE Continuous	Cu. Yds. of Winter Sand	Cu. Yds. of Chem. Added	Total Cu. Yds.
1	[ ]	[ ]			
2	[ ]	[ ]			
3	[ ]	[ ]			
4	[ ]	[ ]			
5	[ ]	[ ]			
6	[ ]	[ ]			
7	[ ]	[ ]			
8	[ ]	[ ]			
9	[ ]	[ ]			
10	[ ]	[ ]			
No. of Times Covered		**Totals**			

Signature of Operator

Remarks:

Courtesy of State of Minnesota Highway Department.

FIGURE 11 OPERATOR'S CHEMICAL USAGE LOG



STATE OF MICHIGAN
DEPARTMENT OF STATE HIGHWAYS
MAINTENANCE DIVISION
Form 450 (Rev. 10/71)
OPERATORS WINTER REPORT

CREW SIZE	ACTIVITY
1	141

WINTER OPERATIONS

ROUTE(S)		EQUIPMENT FINANCIAL CODE
FOREMAN	START DATE	TIME AM PM
OPERATOR	STOP DATE	TIME AM PM
TRUCK #		TOTAL HOURS ACT. 141

ACCOMPLISHMENT

LOAD			SPOT	LEFT	CONTINUOUS	
#	SALT	SAND	TONS/YD	TONS/YD	TONS/YD	MILES
1						
2						
3						
4						
5						
6						
		TOTAL		▨		

MATERIAL

DESCRIPTION	UNIT	TOTAL AMOUNT
SALT	TONS	
SAND	CY. YDS.	
CALCIUM CHLORIDE	BAGS	

Courtesy of State of Michigan
Department of State Highways

FIGURE 12 OPERATOR'S WINTER REPORT

Truck Ident. Operator Foreman

Route(s) Weather

Start Date Time AM PM

Finish Date Time AM PM

Load		Amount Loaded Ton, Yd	Amount Remaining Ton, Yd	Net Used Ton, Yd	Mileage		Prescribed Application Rate (Lb/Mi)	Results Good Fair Poor	Remarks
No.	Type of Material				Odometer	Actual or Estimated			
1									
2									
3									
4									
5									
6									
			TOTALS						

FIGURE 13 GENERALIZED OPERATOR'S DAILY STORM REPORT

- Measures of the weather at the reporting location:
  type of precipitation (dry snow, wet snow, sleet, freezing rain, rain),
  total snowfall,
  total water content of precipitation, and
  brief description of the storm including temperatures, wind, hourly snowfall and/or precipitation rates;

- Quantities calculated from the above information (average pounds of chemical per lane mile per application); and

- Results obtained from the materials applied.

In the many state and local snow and ice control organizations contacted during this study, no storm summary report was found that included all of this above information. A suggested generalized form for a storm summary is shown in Figure 14. The supervisor in each road section is responsible for completing this type of form as soon as possible after the storm or, in the event of a series of small winter operations, at the end of each week. These storm summary reports form the basis for comparisons of the snow and ice control activities in the various road sections of larger administrations, and for development of state-wide and/or annual summaries of snow and ice control activities. The body of data should be large enough so that statistical analysis can be applied if desired.

Annual Chemical Use Report

A final report of interest to the management of snow and ice control with chemicals is an annual report of chemical consumption. Large administrations responsible for snow and ice control such as states, cities, turnpike authorities, and towns may be required to produce or may want a summary report of chemicals consumed. The important parameters for such a report might include:

- Total tons of materials used;

- The average number of applications;

- The total lane miles on which chemicals are applied;

- The total snowfall;

- The total precipitation water content;

- A summary description of all of the storms encountered that winter, including duration, dates, type;

- The calculated quantities
  average pounds of chemicals per lane mile per application and
  average pounds of chemicals per lane mile per measure of the weather such as the inches of snowfall and equivalent precipitation as inches of water;

District No.

Road Section		Material		①	②		Results
No.	Length (Miles)	Type	No. Applications	Total Amount (Tons)	Total Miles of 2-Lane Roads Covered	Rate Lb/Mile of 2-Lane $\frac{2000 \times ①}{2 \times ②}$	
1							
2							
3							
4							
5							
6							

Description of the Weather

Time	Type of Precipitation	Cumulative Amount (in.)	Temperature °F	Notes

Total Snowfall ________ (in.)

Total Precipitation (as Water) ________ (in.)

Date(s) of Storm ________

____

Report by ________

Remarks ________

____

____

____

____

____

____

____

FIGURE 14 STORM SUMMARY REPORT

- Results obtained from the material applied;

- A discussion of the quality of the service provided the traveling public; and

- An estimate of the environmental impact.

Managerial Uses of Accounting Reports

These data gathering and reporting efforts must now be applied constructively to the management of the use of deicing chemicals. They should be used to produce desired levels of snow and ice control for the traveling public with a minimum of chemicals.

Because the pounds of salt applied per lane mile can be easily calculated from the operator's daily storm report, this report is most useful to the road section supervisor in determining if his operators are spreading chemicals at the prescribed rates. When this rate exceeds the prescribed amount, the supervisor can look further to determine if the equipment or the operator is at fault. This report can also be used for inventory records of chemicals used. By checking the reported usage of chemicals drawn from various storages against receipts and inventory of chemicals in these storages, the supervisor can also check the accuracy with which his operators report their usage.

The supervisor's storm summary report is used for deciding when to order replacement materials and how much, for determining if the prescribed rate for salt spreading and the number of applications each storm are providing the desired level of service, for evaluating the performance of subgroups (crews), and for fending off questions and criticisms from other managers and the driving public.

A comparison of storm summary reports from various road sections can be used for analysis of the relative efficiency of each section in terms of measures such as tons per lane mile per inch of precipitation or tons per lane mile per storm.

The annual snow and ice control summary report is useful for interpretation both by officials and by the general public. Good use can be made of this report in requesting additional funds for equipment and storage of materials for subsequent winter seasons, for discussing usages in proportion to the amount of precipitation when talking with environmental groups, and in budgeting the chemical and abrasive requirements for the following winter season (See Chapter VII).

PART FOUR: EQUIPMENT

CHAPTER V

SNOW AND ICE CONTROL EQUIPMENT

The availability of appropriate and functioning equipment and experienced personnel to operate it is the single most important element in a successful snow and ice control program. Although no two organizations have exactly the same program or approach, a commonality exists in the equipment they use. In this section general equipment requirements are discussed and major classes of equipment are described. Wherever possible, advantages and disadvantages are presented, improvements made by individual organizations are noted, and new developments underway are introduced.

EQUIPMENT REQUIREMENTS

Figuring Needs

A winter snow and ice control program for each road section requires a unique mixture of manpower and equipment suited to the average local weather and traffic conditions and the level of service to be maintained. These equipment and labor requirements are usually established over a period of years in response to weather, the level of service, and experience in providing this level of service.

In the course of this study, similarities were noted among the inventories of equipment required for similar road sections. From informal surveys made in the course of a large number of visits to organizations active in snow and ice control, guidelines are established in Table 5 for equipment. These guidelines are a generalized measure for evaluation of present operations, for preparation of budgets for new equipment procurement, and for estimation of manpower requirements for the coming winter season.

Specific equipment and labor requirements for each snow and ice control jurisdiction can be established only after consideration of numerous complex factors, including the distance in lane miles to be serviced, the number of interchanges, the average plowing and spreading speeds, and the level of service. Sometimes a formula is derived including a variety of variables for calculation of equipment requirements.

The Minnesota Department of Highways uses the following formula for calculation of required single- and tandem-axle dump trucks.[4] This requirement is directly related to lane mileage, cycle time, and number of interchanges. Cycle time is the amount allowed for snow removal on through lanes of a given road section to maintain the required level of service under average weather conditions. For interchanges, cycle time is increased to 1.5 times the figure for the adjacent mainline; one truck

Table 5 EQUIPMENT GUIDELINES

Equipment Description	Lane miles per unit of equipment: City and Urban	Lane miles per unit of equipment: Major Interstate	Lane miles per unit of equipment: Rural
Heavy Duty Truck[1] with Spreader[2]	30	20-40	40-60
Heavy Duty Truck with Plow(s)	30	20-25	25-30
Light Duty Truck with Plow[3]	15	50-100	---
Heavy Duty Front-End Loader (greater than 1 cu. yd)	100	100	200
Light Duty Front-End Loader (up to 1 cu. yd)	100	200	400
Road Graders	200-400	100-400	100-400
Heavy Duty Snow Blowers [4]	---	300-1000	300-1000
Light Duty Snow Blowers	200-400	---	---

---

1. Includes large 4-wheel drive vehicles.

2. May be a combined spreader and plow.

3. May include loaders or sanitation vehicles or other plow-equipped multi-purpose vehicles.

4. May be mounted on heavy duty front end loader.

is provided for each 1.5 urban complex interchanges, two urban simple interchanges, or four rural interchanges. The truck requirements for a given road section are calculated by the equation:

$$N_t = \frac{D}{15C} + \frac{N_{A_u}}{1.5} + \frac{N_{B_u}}{2} + \frac{N_{A_r}}{2.5} + \frac{N_{B_r}}{4}$$

where

N_t = number of trucks

D = distance to be plowed in lane miles

15 = average plowing speed in mph

C = cycle time in hours

$N_{A_c} = N_{B_u}$, N_{A_r}, and N_{B_r} = the number of complex (A) and simple (B), urban (u) and rural (r) interchanges.

Of course, any equipment guidelines must be adapted for the particular needs of each unit or road section within an organization. Past experience in each road section, both with the durability or the equipment and with the productivity, has a large influence in determining the numbers, types, sizes, and the particular manufacturer of the various equipments. Much of this past experience can be based upon the various management reporting systems, such as how long it takes a driver to complete his given piece of work, or the maintenance record on a particular piece of equipment.

When equipment requirements are being established, due consideration must be given to the use of outside contractors who may have equipment available during the winter months for augmentation of the existing fleet of equipment in a given jurisdiction. When equipment needs are examined from a total cost point of view (taking into account year-round labor requirements, equipment depreciation, maintenance and garaging requirements), many organizations find that outside, rented contractor equipment (with operators and oftentimes supervisors) provides a cost-effective solution to the winter maintenance problem.

The primary thrust of any winter maintenance program should be to utilize all equipment effectively yet, at the same time not abuse it. Each organization should strive to use its most effective equipment to its maximum capacity at all times and to supplement its use with lesser capacity equipment as required during heavy storm periods. This heavy-duty, first-line equipment (spreaders with ground-speed controllers, and trucks with underbody scrapers, large front-end plows and wing plows) should always be maintained in top working condition.

Labor Requirements

Specific manpower requirements for a given road section are a function of the equipment requirements and a large number of other local variables. General practices that have evolved concerning what constitutes one-man and two-man operations are worth noting, however. The practices of the State of Minnesota Department of Highways are the examples cited here.[5]

Vehicle operation by one man is permissible:

- Whenever weather and road conditions permit a safe operation;
- For single operations such as sanding or chemical application;
- When snowfall does not result in large windrows on traveled surfaces.

Two-man operation of vehicles is used:

- If poor visibility due to blowing snow may affect a safe operation;
- For snowfall that produces large windrows requiring more than one operation to clear the traveled portion of roadway;
- On certain hazardous roadways with extensive left-turn slots;
- For operations involving use of a wing plow; or
- Any other operation considered unsafe for one operator.

Combined one- and two-man operations are used when they are safe and traffic conditions have normalized so that operations are less restricted. The types of work performed under this arrangement are as follows:

- Removal of snow from shoulders and adjacent slopes to provide additional space for the next storm;
- Removal of snow from intersections and other locations where high banks interfere with visibility;
- Resumption of normal maintenance operations; and
- Performance of any operation that will return traffic movements back to normal.

Equipment Reliability

Careful attention should be paid to routine maintenance of all equipment and especially the first-line equipment which is crucial to the winter operations program. The equipment maintenance program should focus on minimizing downtime for the first-line equipment so that it is available during the time of greatest need. Such a maintenance program requires that routine overhauls be completed during the summer and fall months, that key components of the equipment be stockpiled at the locations where it might be needed and that the maintenance personnel are available who can, by all means within their capability, get key pieces of equipment in operation in the event of breakdowns.

TRUCKS

Trucks are the backbone of all snow and ice control programs. Used for plowing and/or spreading chemicals and abrasives, they come in all sizes and capacities depending upon their use. They range from small four-wheel drive utility plows to tractor-trailer rigs for chemical/abrasive spreading on long, straight stretches of road. The choice of a truck is often controlled by its intended year-round purpose, which can result in equipment that is less than optimal for snow and ice control.

The five-ton two-axle heavy-duty truck shown in Figure 15 is the overwhelming choice of all snow and ice control organizations. Specifications for this type of truck are summarized in Table 6. Ideally, for snow and ice control this type of truck is equipped with a chassis-mounted spreader and a plow or combination of plows. The chassis-mounted spreader makes fuller use of the truck's rated capacity than does a truck with a dump body and a slip-in spreader. Chassis-mounted spreaders, however, require dismounting of the spreader in the spring and replacement with a dump body for summer operations.

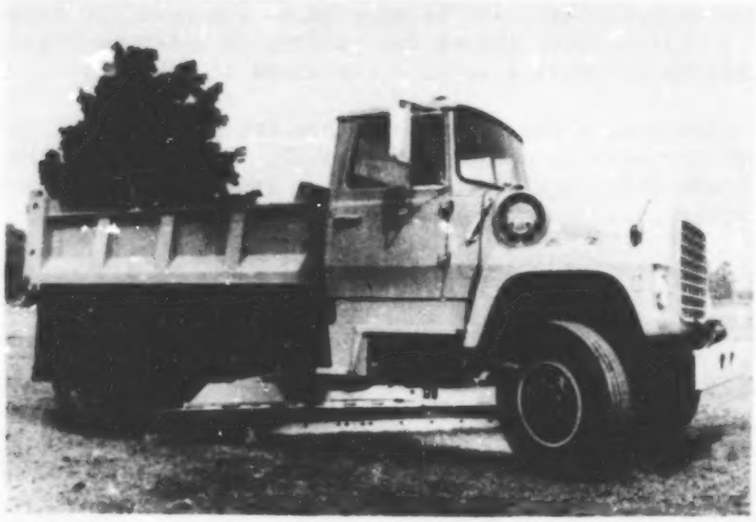
The advantages of equipping such a truck with a dump body and a slip-in type spreader are two-fold. The twice annual changing over of spreader bodies is eliminated, and, through the use of a suitably designed storage rack, the slip-in spreader can be removed during those periods in the winter when there is little snow, and the trucks can be used for other operations. A disadvantage of the slip-in type spreader is that it does not make full use of the capacity of the truck. Because the tare weight of the truck, dump body, and empty spreader is greater than that of the truck and chassis-mounted spreader, less capacity is available for material for a given gross vehicle weight. Additionally, the center of gravity of a loaded slip-in spreader is higher than that for a chassis-mounted spreader. A solution to this problem is the use of a tailgate type spreader in conjunction with a dump body.

Many organizations utilize lighter-duty trucks of from 2-ton to 3-ton capacity for plowing operations. These trucks are seldom equipped with spreaders and are often used for other maintenance operations, e.g., as sanitation trucks, for landscape work, during sign and lane marker painting operations, and for general utility work. Specifications for this medium-duty truck are shown in Table 6.

The versatile four-wheel-drive, three-quarter ton pickup truck is being used increasingly for plowing. Equipped with a two-way power angling plow, it is useful for plowing in tight areas, such as in service areas

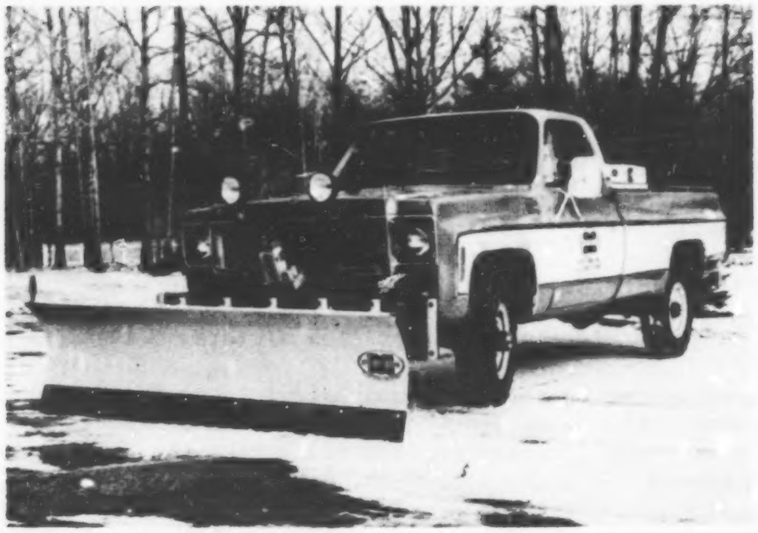
Table 6 TYPICAL DESIGN SPECIFICATIONS FOR TRUCKS COMMONLY USED FOR SNOW PLOWING AND FOR SPREADING OF DEICING CHEMICALS

Specification	Light-duty truck	Medium-duty truck	Heavy-duty truck
Truck capacity (nominal rating)	.75 ton	2-3 tons	4-5 tons
Gross vehicle weight	7,500 lb	24,000 lb	35,000 lb
Axle capacity			
front	3,500 lb	7,000 lb	12,000 lb
rear	5,300 lb	17,500 lb (two-speed)	23,000 lb (two-speed)
Engine			
type and fuel	6-cylinder/gasoline	V-8/diesel	V-8/diesel
horsepower	125 maximum net	150 net	200 net
cubic inch displacement (CID)	300	525	635
torque	230 ft lb	320 ft lb net	465 ft lb net
Transmission	4-speed manual (2-speed transfer case)	5-speed (fifth direct)	5-speed (fifth direct)
Steering	power	power	power
Brakes	self-adjusting (cab-adjusting dual hydraulic emergency)	full air brakes	full air brakes
Springs			
front	1,750 lb	4,050 lb	6,000 lb
rear	2,700 lb	10,500 lb	11,600 lb
auxiliary	550 lb	2,250 lb	2,250 lb
Electrical system			
alternator	55 A	70 A	70 A
batteries	12 V - 70 Ah	Dual 155 Ah	Dual 204 Ah
lights	spot light, plow lights, rotating beacon	Body markers, cab clearance, plow lights, rotating beacon	Body markers, cab clearance plow lights, rotating beacon
Chassis wheel base	131 in.	154 in.	162 in.
Frame section modulus	5.5 in.^{3}	19 in.^{3} reinforced (36,000 psi steel)	15.5 in.^{3} (115,000 psi)
Rim size	16.5 in. x 6.0 in.	20 in. x 7.0 in. cast spoke	20 in. x 8 in. cast spoke
Tire size and ply	tubeless 8:00 x 16.5 8 ply rating	9:00 x 20 12 ply rating	11:00 x 20 14 ply rating
Miscellaneous			
mirrors	dual 7 in. x 11 in.	16 in. x 7 in. West Coast	16 in. x 7 in. West Coast
heater	heavy duty	heavy duty	heavy duty
anti-freeze protection	10°F below anticipated minimum	10°F below anticipated minimum	10°F below anticipated minimum
engine block heater	yes	yes	yes



Courtesy of Root Spring Scraper Company, Kalamazoo, Michigan.

FIGURE 15 FIVE-TON, TWO-AXLE, HEAVY-DUTY TRUCK WITH UNDERBODY SCRAPER



Courtesy of Meyer Products, Inc., Cleveland, Ohio.

FIGURE 16 FOUR-WHEEL-DRIVE, 3/4-TON PICKUP TRUCK WITH PLOW

and rest areas on turnpikes, and is sometimes even used for main-line operations. A typical unit set up for plowing is shown in Figure 16; the specifications for such a vehicle are shown in Table 6.

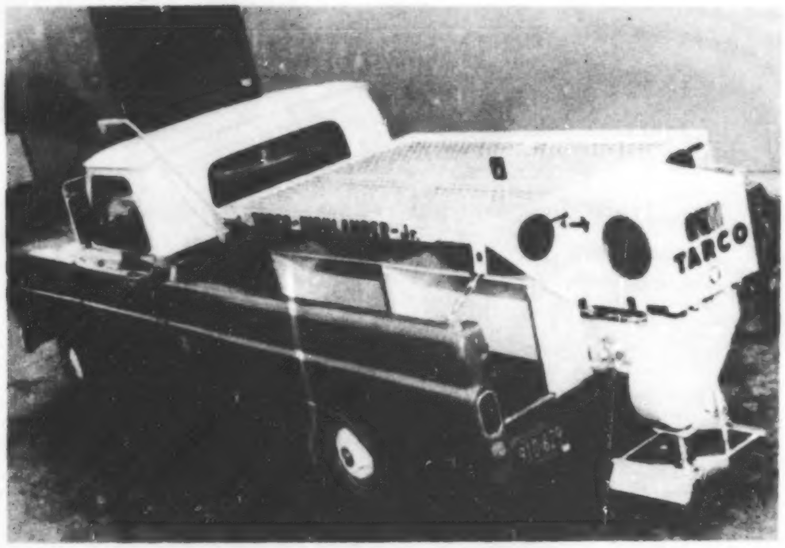
In some organizations, a small three-quarter ton pickup truck is equipped with a 1.5-yd^3 spreader as shown in Figure 17. Often used by the foremen for patrol, these units are useful for quick application of chemicals as needed and, often when larger spreaders breakdown, for backup.

Each truck should be equipped with lights and other safety equipment in accordance with all state and federal regulations. As a minimum these should include:

- chassis delineation lights,
- a revolving flashing light mounted on the top of the cap,
- two alternately flashing warning lights mounted near the top extreme corners of a chassis-mounted hopper or on the upper extreme of the back end of a dump body,
- a set of headlights that clear the front-end plow,
- a fixed spotlight aimed at the tip of any wing plow to be attached,
- reflector flare and fuses,
- first aid kit,
- two-way radio,
- wheel chocks,
- cab map lights,
- flood light on spreader discharge area, and
- two large outside-mounted rear view mirrors.

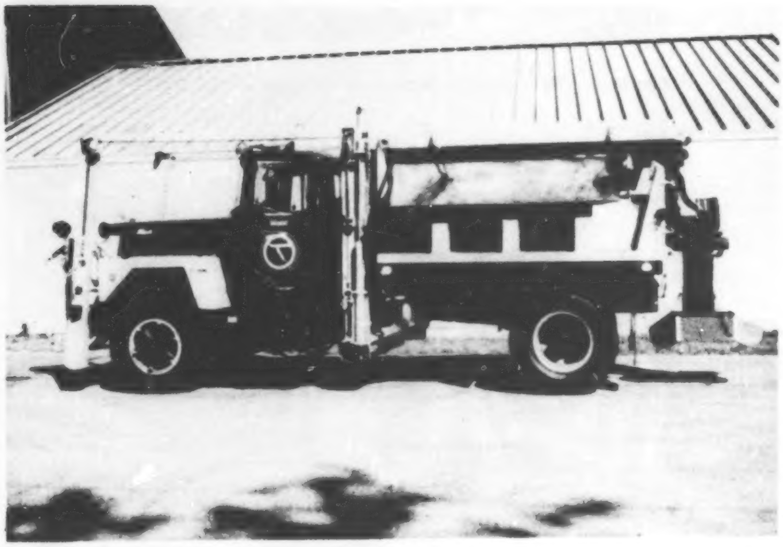
With the advent of the current fuel and material shortages, more care should be given to the selection and specification of trucks and their components. The sharp increase in fuel costs make the diesel almost mandatory in trucks above the 15,000-lb. G.V.W. class. Certainly, soft undercoating and optional tougher paints and primers should be specified for all state and municipal equipment whenever possible. The lower mileage/time usage ratio of municipal trucks favors the selection of fiberglass cabs and other non-corrosive components.

Choice of the smallest displacement engine that will do the job effectively will result in continued fuel savings. Modern multi-range automatic transmissions are slowly coming into their own. These units, coupled



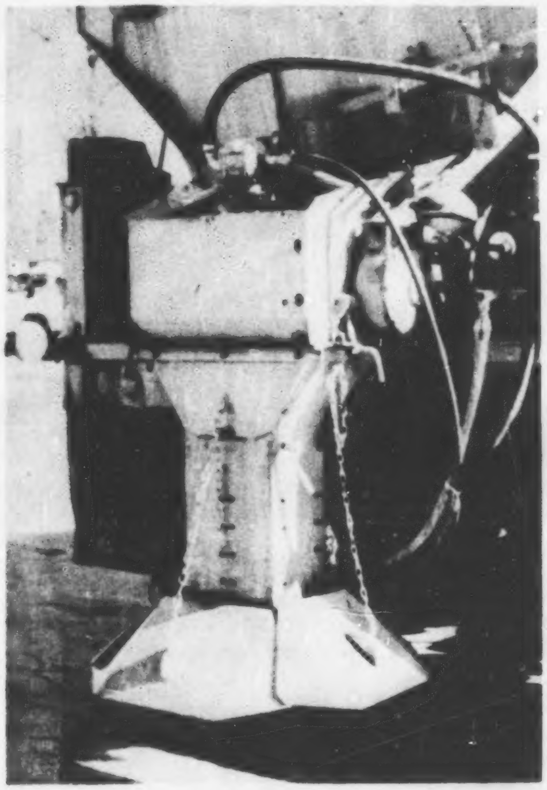
Courtesy of Tarrant Manufacturing Co., Saratoga Springs, N.Y.

FIGURE 17 THREE-QUARTER-TON PICKUP TRUCK WITH 1.5-YD^3 SPREADER



Courtesy of Tarrant Manufacturing Co., Saratoga Springs, N.Y.

FIGURE 18 VEE-TYPE HOPPER SPREADER



Courtesy of Massachusetts Department of Public Works.

FIGURE 19   DETAILS OF SPINNER AND SPREADER

with the proper engine, can save fuel, increase equipment longevity, and reduce operator training time and fatigue.

Increased complexity in mandatory safety and emission equipment requires more preplanned maintenance in order to reduce downtime. Comprehensive maintenance manuals should be specified when new equipment is procured, especially for components like the new anti-skid devices that may be unfamiliar to maintenance personnel. Perhaps additional training for mechanics at the time of purchase should also be considered. This is also a very good time to review requirements for spare parts with an eye on the increasing lead time necessary to obtain replacement parts.

With increases in truck costs of 1%/month or more predicted for the next few years, it behooves the buyer to choose trucks and options that will yield maximum service and longevity. In general, this means selection of trucks of simplest, most rugged designs and that are most easily maintained.

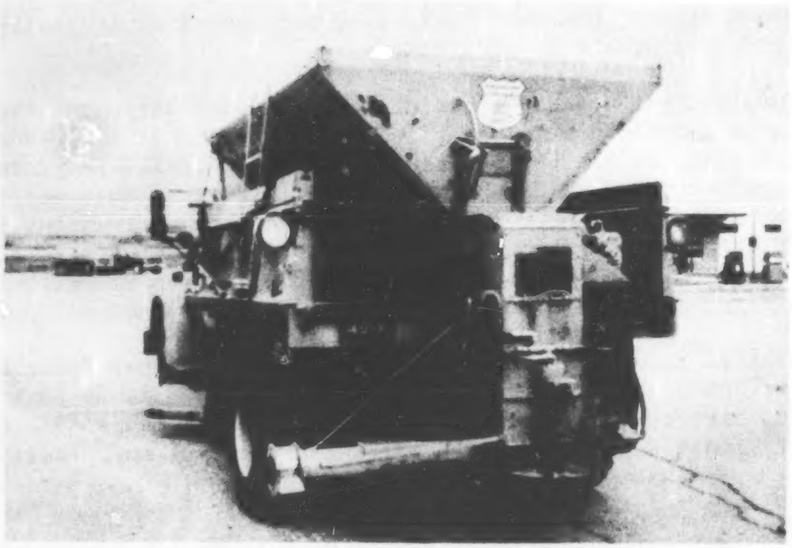
SPREADERS

Snow and ice control programs that use granular chemicals and/or abrasives require a means of applying these materials on the roadway within closely controlled areas. There are several techniques.

Earlier when sand, cinders, and/or salt were used, a laborer (sometimes two) standing near the back of a dump truck would fling shovelsful of material in a spreading pattern over the back end of the truck as the driver slowly proceeded down the highway. Later, as rock salt came into more general use, some organizations installed a large funnel on top of a 2-in. I.D. tube, which discharged salt behind the left rear wheel of the truck. Salt scooped into the funnel by a laborer was discharged out of the tube into a windrow that was laid down behind the left rear wheel and near the center or crown of the road. The trucks could be driven at a higher rate, and considerably more road could be treated during a storm. Often the truck was equipped with a built-up canvas cover to protect from the elements those rugged individuals who shovelled.

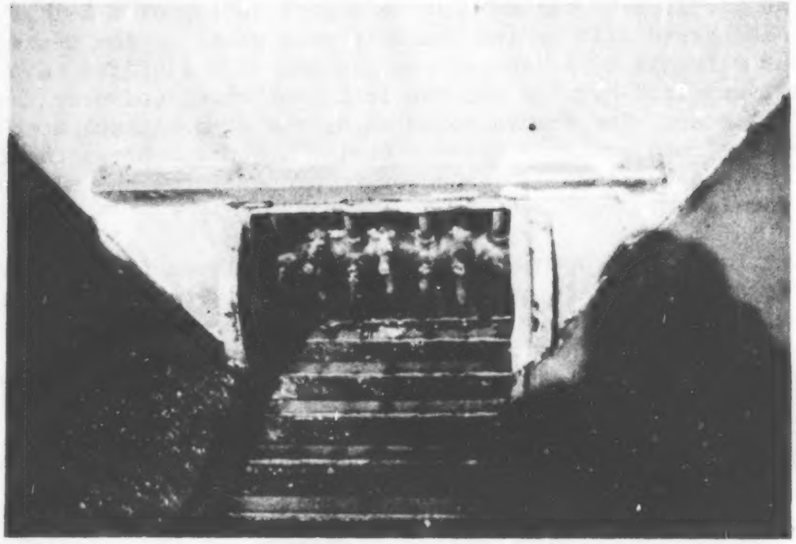
Meanwhile, dry fertilizer spreaders were being developed for the agricultural industry. These designs were adapted quite naturally to the spreading of rock salt and abrasives. The modern outgrowth of these spreaders is the focus of our attention in this manual. The most popular basic types of spreaders generally found in snow and ice control programs are described.

By far the most popular type of spreader has a Vee-type hopper, which is either chassis-mounted or slips into a dump body and has a hydraulically powered, chain-type conveyor. A slip-in unit is shown in Figure 18. Chemicals and/or abrasives removed from the hopper by the conveyor fall down a chute onto a rotating spinner which distributes the material onto the roadway. Details of the spinner and of the spreader are shown in Figure 19. A system of flaps is often used to limit the spread pattern from the spinner, particularly for application of salt on high-speed roads.



Courtesy of State of Michigan Department of Highways.

FIGURE 20 MODIFICATION TO SPREADER



Courtesy of State of Michigan Department of Highways.

FIGURE 21 LUMP BREAKER

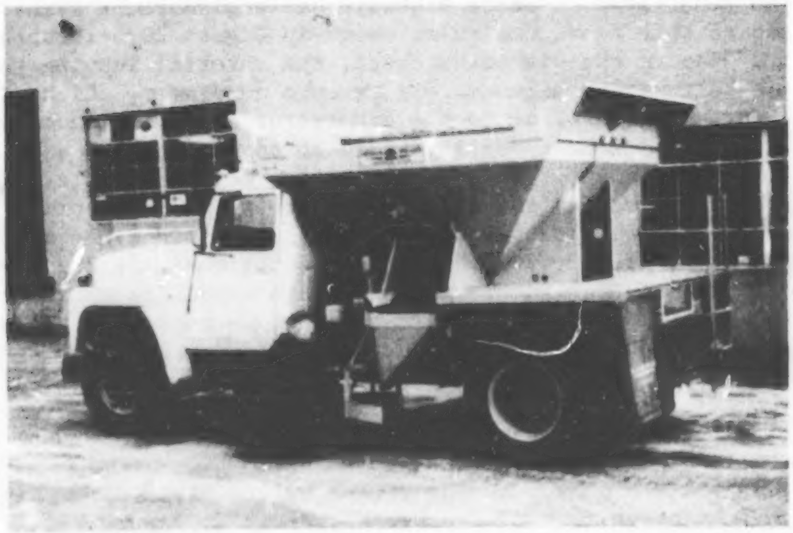
The Michigan Department of State Highways has engineered a versatile modification of this basic design as shown in Figure 20. Through remote control of a flap in the discharge chute, the material leaving the end of the chain belt can be directed either onto a spinner, which gives a full-width spread pattern, or onto a transverse auger, which moves the material through the tube shown in Figure 20 to an impeller mounted onto an end of the auger shaft. This impeller discharges the material to the rear as the truck proceeds forward. The rearward velocity of the material closely matches the forward velocity of the truck; since the material lands on the road at zero velocity with respect to the road, it does not bounce or slide off the driving lanes. The discharge scroll on the left-hand impeller is pointed downward approximately ten degrees, and the discharge end has been modified slightly to ensure that material is not thrown up into the air before it lands on the road surface. By reversal of the transverse auger, the material can be discharged in a windrow from the opposite end of the transverse tube shown in Figure 20.

An additional feature of the spreader used by the State of Michigan Department of Highways is the lump breaker shown in Figure 21. This breaker rotates as the flite chain moves, and the fingers crush all of the lumps before they pass through the spreader gate. Spreaders should be equipped with screens with 2.5 to 3 inch openings on the top of the hopper to ensure that all material entering is of sufficiently small size so that it will pass through the narrower tailgate opening at the discharge end of the chain-belt conveyor. On large spreader units, a pointed bridge roof is installed over the chain-belt conveyor to keep the full load of the salt or abrasive material from resting on the chain belt. This bridge makes it easier for a hydraulic system to start moving material when the hopper is fully loaded.

Spreaders with chain-type conveyor belts have a controllable gate at the discharge end to limit the amount of material leaving the hopper on the chain-belt. An index system painted on the back of the hopper is used for setting the opening of this gate.

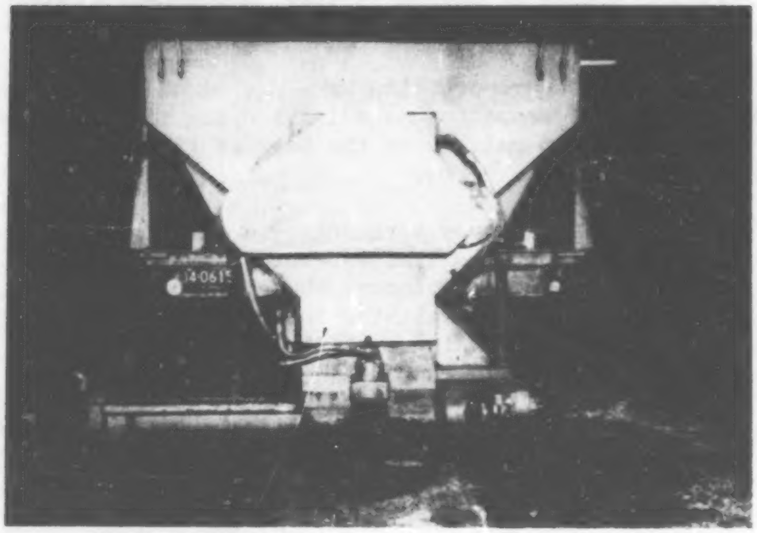
Some manufacturers offer auger-type spreaders, in which a single auger located axially along the bottom of the Vee-bottom hopper conveys salt to the chute above a distribution spinner. Usually these spreaders are equipped with a separately driven agitator located above the main auger to prevent the material from bridging over the auger and stopping flow.

Several manufacturers offer a Vee-type hopper model with a chain-belt conveyor that discharges material out of the front end of the hopper and into a chute that carries the material sideways to a spinner located midway between the front and rear axles of the truck. An advantage to this type of delivery is that salt or abrasive materials are discharged in front on the drive wheels of the truck, thereby insuring added traction particularly on icy roads. Another advantage is that the spreader unloads from the rear toward the front, and the remaining load always remains better distributed between front and rear wheels of the truck.



Courtesy of Swenson Manufacturing Company, Lindenwood, Illinois.

FIGURE 22 ONTARIO SPREADER



Courtesy of State of Michigan Department of Highways.

FIGURE 23 REAR VIEW OF MICHIGAN W-BOTTOM SPREADER

Short Conveyor Belt Spreader

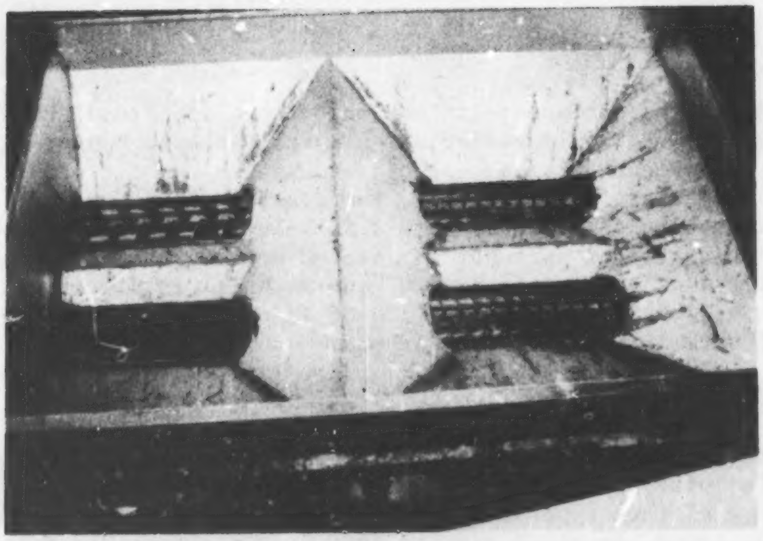
A spreader built to the design specification of the Province of Ontario is shown in Figure 22. This spreader has a pyramid-shaped hopper with a capacity of 4 yd^3. Because the amount of material in contact with the short side-delivery chain belt is small, the starting load on the hydraulic system is considerably less than that in a full-length chain-belt conveyor. The spinner on this type of spreader is located between the front and rear wheels of the truck on the driver's side, and material is discharged in front of the drive wheels. A small deflector is used to limit the distribution of material on the road surface.

Low Center of Gravity Spreader

The Michigan State Department of Highways has developed an interesting W-bottom spreader with double dual augers shown in Figure 23 and 24. The important feature of this type of spreader is that for a given load size, the hopper has a lower center of gravity than does a comparably sized Vee-bottom spreader, and better use is made of existing volume within the truck. Each pair of augers rotates in opposite directions, and all augers rotate at the same speed. They feed a common chute, which in turn feeds a cross auger or spinner as already described. The quantity of material is regulated by the speed of the augers and restrictors located in the exit discharge of the auger.

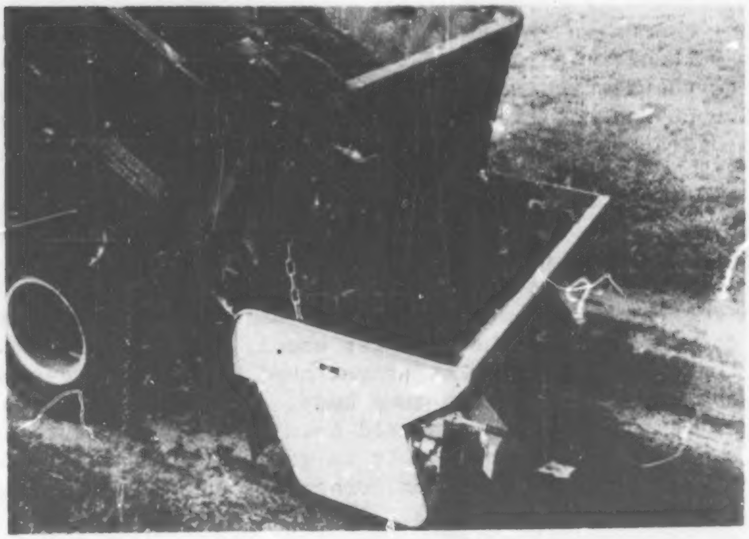
Spreader Towed Behind a Dump Truck

The spreader unit shown in Figure 25 is towed behind a standard dump truck and provides a mechanism whereby chemicals and/or abrasives are applied in proportion to the distance which the vehicle travels. This unit, developed in Europe and now finding application in this country is a genuine ground-speed-controlled spreader. The dispersement of the material from its hopper is effected by a rotating roller, which is driven by the wheels of the spreader. The rate of material spread is controlled by a rubber flap which presses against the material-dispensing roller. In operation, the truck driver raises his dump body to discharge approximately 1.5 yd^3 of salt or sand into the spreader hopper. The roller is then engaged to the wheel drive and salt is dispensed in proportion to the rotation of the spreader wheel. No operating controls are needed in the driver's cab. The driver need only stop occasionally to refill the hopper by raising his dump body. An advantage of this type of spreader is that the salt is laid down directly under the spreader and it is not thrown to either side. It is good for applying salt to ramps, interchanges, parking areas, and other places where the material should not be spread around very much. It is also very effective in applying salt to an area such as a passing lane which needs treatment long after the traffic lane has become dry. Some organizations find this type of spreader useful for combating the early fall storms or the late spring storms, which are usually small, and when the larger spreaders are not mounted on truck chassis. It is also useful during periods when the large heavy-duty spreaders are inoperative.



Courtesy of State of Michigan Department of Highways.

FIGURE 24 INTERIOR VIEW OF HOPPER, MICHIGAN W-BOTTOM SPREADER



Courtesy of the Epoke Company, Denmark.

FIGURE 25 SPREADER TOWED BEHIND A DUMP TRUCK

The principal advantages of this type of spreader are that they are inexpensive to buy and maintain when compared to a chassis-mounted spreader (they cost about one-third that of a slip-in hydraulically controlled spreader); they make good use of existing dump trucks, particularly the 2-3 ton size; and they can be ready for service in just a few minutes. The disadvantages are that they do not spread while backing up, they cannot spread material on more than one lane at a time (not useful for multilane expressways), and the truck must raise the dump body periodically to fill the spreader. (This operation requires that the truck pull off of the highway and stop. Filling on the run is dangerous because the raised dump body may catch overhead branches, wires and bridges).

Spreader Modifications for Different Materials

Hydraulic spreaders utilize a hydraulic motor attached to a 50:1 gear reduction unit, which drives the chain belt. The heavy starting loads and the slow speeds at which the motor runs during spreading of chemicals at low rates place an extreme load on this motor. The Massachusetts Department of Public Works uses a three-speed gear box between the hydraulic motor and the 50:1 gear reduction unit, which drives the chain-belt. This gear box has 3:1 reduction, a 2:1 reduction, and a direct drive. The 3:1 reduction is used during salt spreading, the 2:1 reduction is used for spreading a mixture of sand and salt (50%), and the direct drive is used for spreading sand. With the 3:1 reduction, the hydraulic motor runs at an efficient torque and speed, and the chain belt is pulled at a speed that allows the spreader to deliver material at a rate as low as 75 lb per lane mile when the tailgate opening is 1 in.

The hydraulic system used to drive these spreaders is also used for controlling plows that may be attached to the truck. The preferred pump-drive system is one attached through a coupling to the crankshaft pulley at the front end of the engine. The engagement of the pump occurs by means of a mechanical coupling, which must be made up when the engine is stopped, or by means of a mechanical clutch that can be shifted manually or by air pressure. Some hydraulic systems are driven from the truck power take-off located on the transmission. The hydraulic oil reservoir should be of sufficient size that the oil can be cooled to a steady-state operating temperature during the worst operating conditions. Often, these reservoirs are mounted on the chassis directly behind the cab.

Some spreader units, particularly older units, and most of those with small capacity, are powered independently by a small air-cooled gasoline engine, which is coupled through a centrifugal clutch. Remote on-off controls and throttle setting are the major means of regulating these spreaders.

GROUND-SPEED CONTROLLERS

A recent addition to the control system for hydraulic chemical spreaders is a control unit, which synchronizes the spreader feed mechanism with the forward motion of the truck. This automatic type of control relieves the driver of the burden of manual control of the application rate of salt

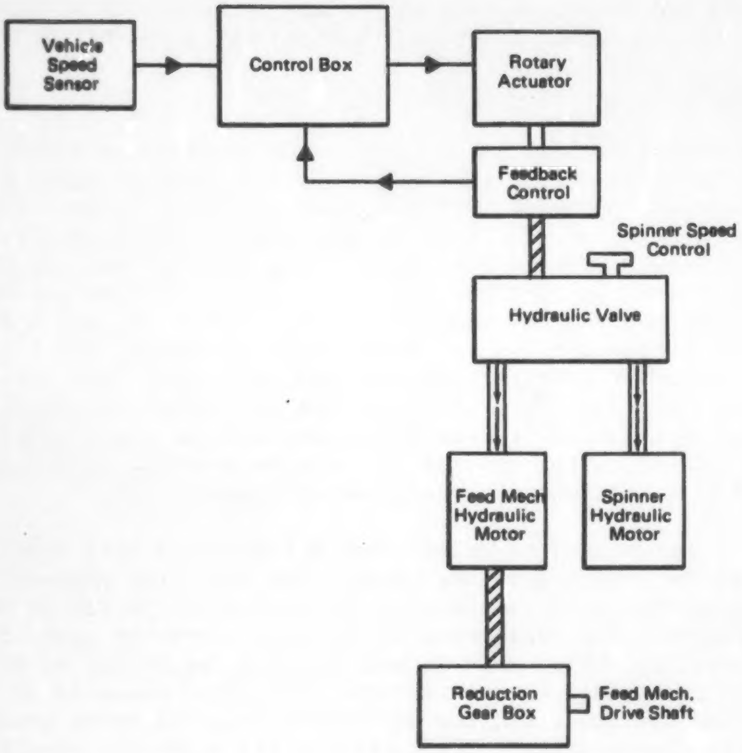

Vehicle Speed Sensor
Control Box
Rotary Actuator
Feedback Control
Spinner Speed Control
Hydraulic Valve
Feed Mech Hydraulic Motor
Spinner Hydraulic Motor
Reduction Gear Box
Feed Mech. Drive Shaft

FIGURE 26 OPEN-LOOP GROUND-SPEED CONTROLLER: SENSOR AND CONTROL CIRCUIT

and/or sand or other chemicals during a storm; thus he is free to focus his attention on driving, plowing, and other responsibilities.

Ground-speed controllers are a most important piece of equipment for controlling the rate of chemical application. More importantly, they enable spreading of chemicals only when the truck is in motion and go a long way toward eliminating the wasteful spreading of chemicals that inevitably occurs when a vehicle is stopped, for one reason or another, and the spreader continues to operate. Further, these ground-speed controllers are capable of spreading chemicals in proportion to the speed at which the truck is traveling. At slow speeds, a small amount of chemical is spread, whereas, at high speeds, larger quantities are released. The net effect is that a uniform quantity is spread on each mile the truck goes.

The basic operating principles of all ground-speed controllers require that the rate of forward (or backward) motion of the vehicle be measured. In most control systems, the rate of forward motion is monitored at the back end of the transmission by the speedometer cable pickup, which senses rotation of the drive shaft. Other points at which truck motion can be sensed are in the front wheel or an idler wheel that rides on top of one of the rear wheels and drives a rotary motion sensor. The purpose of the sensor is to provide a signal proportional to its rotary motion. One commonly-used sensor includes an eight-pole permanent magnet that, as it rotates past a fixed coil, produces the desired signal. Another sensor uses a photoelectric cell located directly opposite a tungsten filament lamp. Between these two units and attached to the rotating element of the sensor is a card with multiple, evenly spaced perforations around its perimeter. As it passes between the photoelectric cell and the incandescent light, this card interrupts the light, thus providing for the photodetector, pulses of light that are in proportion to the rotational speed of the sensor.

There are two basic types of ground-speed controllers: the open-loop and the closed-loop.

Open-Loop Control System

This type of controller utilizes a single sensor usually attached at the speedometer cable takeoff point on the transmission. Pulse signals from this sensor are fed to the control circuit shown schematically in Figure 26 where the signal is amplified, compared with a calibration signal and with a control signal, which is in proportion to the desired amount of salt. This signal is then used to control a motor that opens or closes the hydraulic valve controlling rate of chemical flow from the spreader.

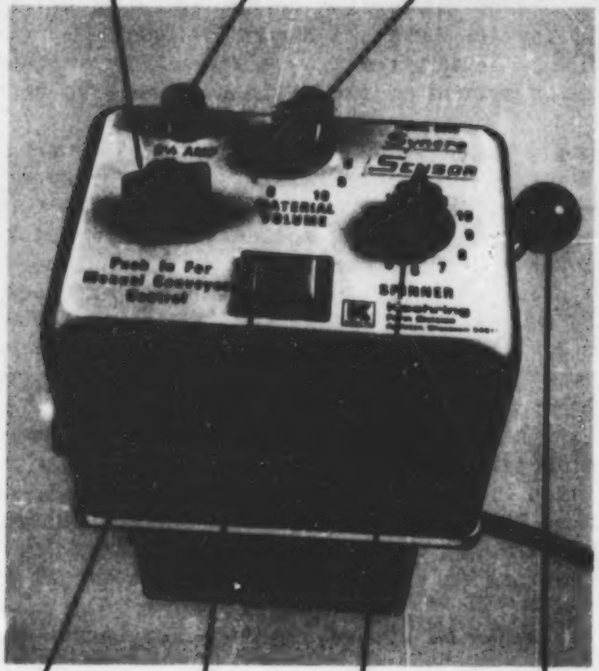
A typical open-loop controller is shown in Figure 27. This unit is designed to sit on top of a standard in-the-cab hydraulic control valve for a hydraulic spreader. A desirable feature of this control unit is that the operator can control manually the operation of the spreader in the event of a failure in any part of the control system.

MANUAL CONVEYOR SPEED CONTROL SELECTOR KNOB

AUTOMATIC SYSTEM MAIN FUSE 6¼ AMP

MATERIAL VOLUME SELECTOR KNOB

USED ONLY WHEN AUTOMATIC SYSTEM IS IN OPERATION


6¼ AMP
0
10
MATERIAL VOLUME
Push In For Manual Conveyor Control
SPINNER
Koehring

GENERATOR FUSE (INSIDE COVER) 1.0 AMP

PUSH BUTTON SWITCH FOR AUTOMATIC SYSTEM

BUTTON LITES UP WHEN IT IS 'ON.'

SPINNER SPEED SELECTOR KNOB

MANUAL OPERATION ONLY (NOT PART OF AUTOMATIC SYSTEM)

CONTROL VALVE LEVER

SHUTS OFF SPREADER

Courtesy of Koehring Farm Division, Appleton, Wisconsin.

FIGURE 27 TYPICAL CAB CONTROL UNIT FOR OPEN-LOOP GROUND-SPEED CONTROLLER

The advantages of the open-loop control system is that it is simple and requires only one sensor. The disadvantages of the open-loop system are that it cannot compensate for changes in temperature of the hydraulic oil or other degradations in the hydraulic system, and temperature sensitivities of the electronics in the control circuit may provide inaccuracies in the calibration.

Closed-Loop Control System

A closed-loop control system utilizes two sensors, one usually attached to the transmission takeoff point of the speedometer and the other attached to the output shaft of the feed mechanism of the spreader unit. The control system operates on the principle shown schematically in Figure 28. The signal from the truck-speed sensor is compared with the control input signal (which is proportional to the desired amount of salt) and to a feedback signal from the output shaft of the feed mechanism. The signal from the forward-motion sensor of the truck tells the control system that spreading can commence. The control setting on the controller tells the controller how to set the hydraulic valve opening for the speed at which the truck is moving. The sensor on the output shaft of the spreader feeds back a signal which indicates to the controller whether or not the spreader is spreading the desired amount of material. With this type of controller, a feed mechanism control accuracy of ±2% can be achieved under all driving conditions in the vehicle speed range from approximately 0.2 to 45 mph.

Figure 29 shows a ground-speed controller unit that utilizes a photoelectric feed mechanism and vehicle-speed sensors and that has a manual override capability for controlling the hydraulic circuit in the event of a failure.

Some ground-speed controller units are equipped with a control feature that allows an additional amount of salt to be spread on critical areas such as at intersections, on bridges, or on steep portions of hills. This "blast" switch usually provides approximately 20% additionaly material for one-time application to critical areas.

LIQUID DISPENSING SYSTEMS

Many jurisdictions have been experimenting recently with prewetting of salt with various materials in order to speed up its action, particularly at temperatures near the lower limits at which salt is useful, and to keep the material from bouncing off the road when it is spread. This technique is discussed in Chapter IV.

A typical truck-mounted calcium-chloride dispensing system shown schematically in Figure 30 has a 60-gallon stainless steel or fiberglass tank fitted into the area between the truck dumpbody and the spreader hopper.[6] The positive-displacement pump shown is sometimes replaced with an electrically driven, magnetically coupled, all-plastic pump and a solenoid control valve. A spray bar (sometimes fitted with fan nozzles) dispenses liquid calcium chloride into the discharge chute of the spreader.

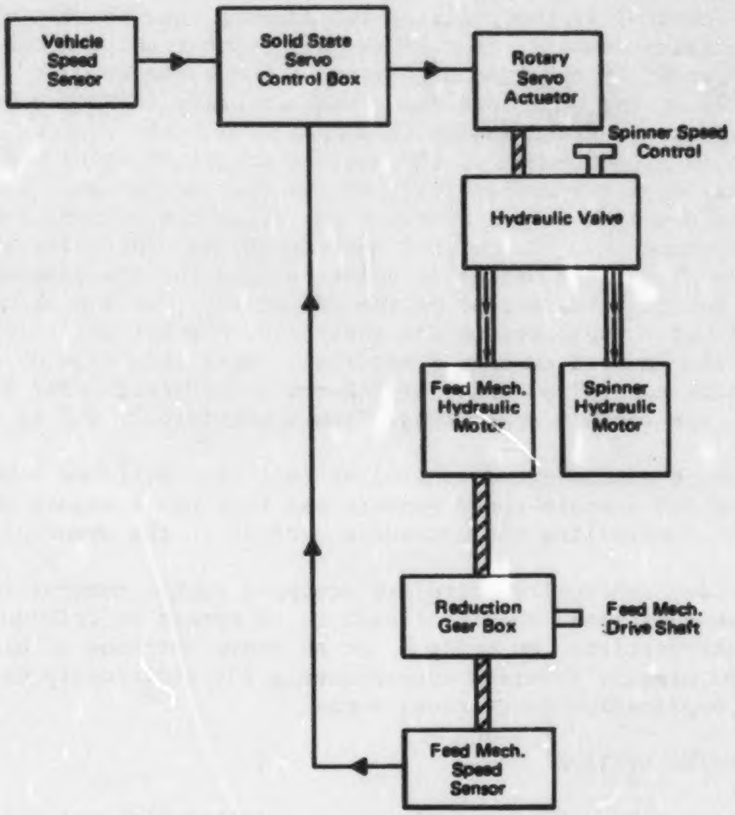
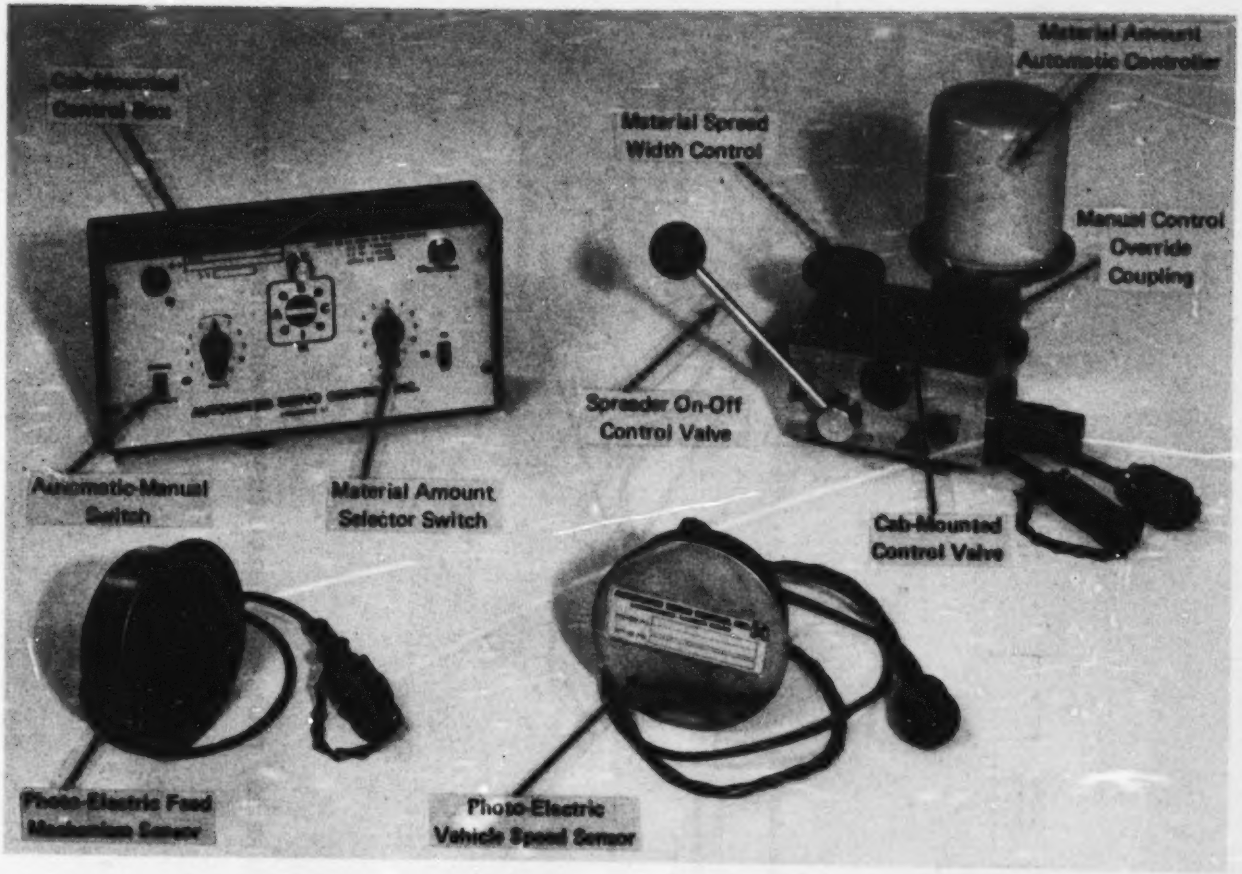

Vehicle Speed Sensor
Solid State Servo Control Box
Rotary Servo Actuator
Spinner Speed Control
Hydraulic Valve
Feed Mech. Hydraulic Motor
Spinner Hydraulic Motor
Reduction Gear Box
Feed Mech. Drive Shaft
Feed Mech. Speed Sensor

FIGURE 28 CLOSED-LOOP GROUND-SPEED CONTROLLER: SENSOR AND CONTROL CIRCUIT


Cab-Mounted Control Box
Material Spread Width Control
Material Amount Automatic Controller
Manual Control Override Coupling
Spreader On-Off Control Valve
Automatic-Manual Switch
Material Amount Selector Switch
Cab-Mounted Control Valve
Photo-Electric Feed Mechanism Sensor
Photo-Electric Vehicle Speed Sensor

Courtesy of Swenson Manufacturing Company, Lindenwood, Illinois.

FIGURE 29 GROUND-SPEED CONTROLLER WITH PHOTOELECTRIC FEED MECHANISM, VEHICLE-SPEED SENSORS, AND A MANUAL OVERRIDE

5

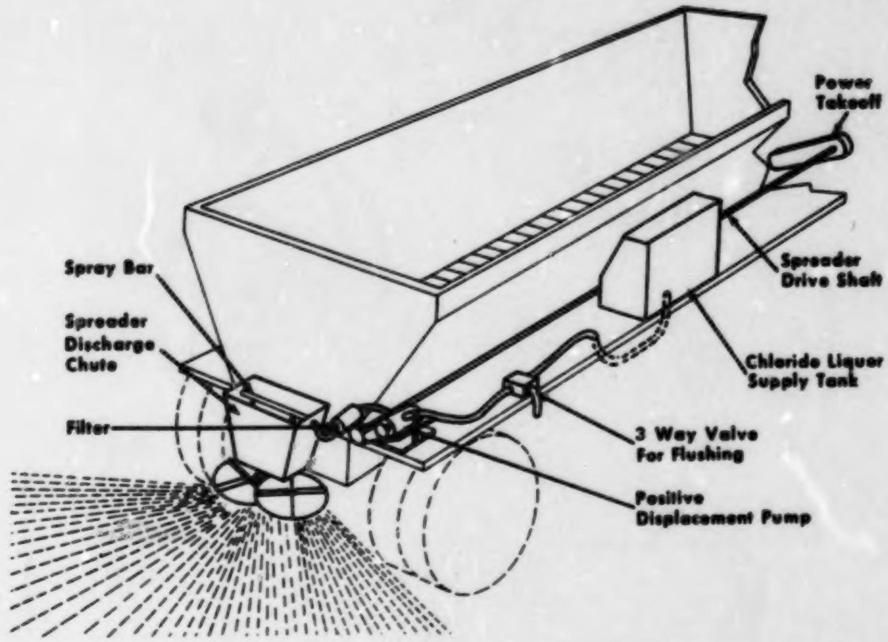

Power Takeoff
Spray Bar
Spreader Drive Shaft
Spreader Discharge Chute
Chloride Liquor Supply Tank
Filter
3 Way Valve For Flushing
Positive Displacement Pump

FIGURE 30 TRUCK-MOUNTED CALCIUM CHLORIDE DISPENSING SYSTEM[6]

A disadvantage of prewetting salt with calcium chloride solution or other solutions is that it requires additional equipment, special operating procedures, and storage tank for 4,000-8,000 gallons of liquid material at each maintenance depot. Each truck-mounted system must be flushed at the end of a storm. Also, the addition of calcium chloride accelerates the corrosion of equipment because it attracts water moisture from the air.

SNOW PLOWS

After snow has begun to accumulate there comes a time when chemical operations must cease and plowing must begin. This usually occurs when about 0.5 in. of snow has accumulated and more is predicted. A multitude of plows are available for snow and ice control work, and the particular design should be chosen to match the type of snow condition expected in the area, the nature of the road system (high-speed arterial, or downtown, or residential areas), and the truck that will be used to propel the plow. Summarized in the following paragraphs are description of the major types of plows presently in use.

High-Speed Plow

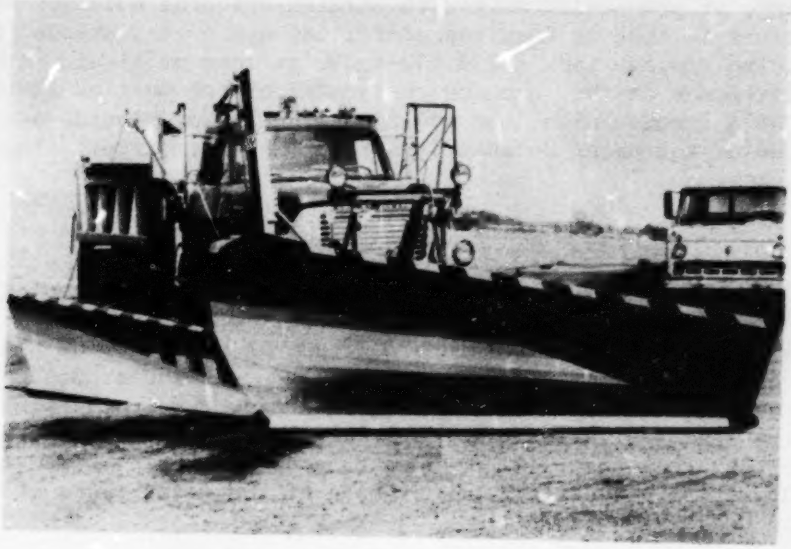
The high-speed plow shown in Figure 31 is characterized by a conical-shaped moldboard, which is small on one end and large on the other end. This type of plow is typically used on very large vehicles (weighing 5 tons or more) and plows the snow in only one direction, usually to the righthand side of the road, although some lefthand, high-speed plows are in service. The moldboard is contoured so that the snow leaves from the large end on the blade and is directed out to the side. In light blowing snow, this feature improves the visibility of the driver so that he can achieve a higher plowing speed. The contoured moldboard provides maximum lateral casting distance, and minimum power is also required to push the plow.[7]

Two-Way Plow

A popular plow for all-around use is the two-way, power reversible, straight-edged plow with a constant cross section moldboard shown in Figure 32. This popular plow is made in sizes ranging from 8 feet up to 14 feet in width and is used on vehicles ranging in size from utility vehicles up to the largest four-wheel drive plow trucks made. The power-angling characteristics are useful for plowing either to the right or to the left on multiple-lane roads and, upon occasion, are used for pushing snow directly ahead of the truck (e.g., for clearing of parking areas). The constant cross section of the moldboard limits the speed at which this type of plow can be used in light snow, because the snow has a tendency to come up over the front of the moldboard at high speed thus reducing the visibility of the driver.

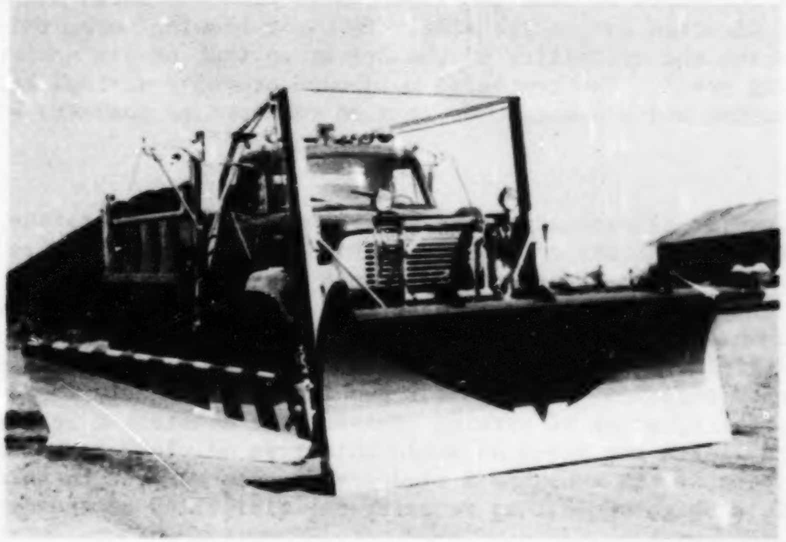
Two-Way High-Speed Plow

A compromise between the high-speed and the two-way plow is the two-way, high-speed plow. This plow has a straight cutting edge and a double-formed moldboard, which is capable of casting snow either to the right or to the left depending upon the orientation of the plow.



Courtesy of Frink Sno-Plows, Clayton, New York.

FIGURE 31 HIGH-SPEED PLOW



Courtesy of Frink Sno-Plows, Clayton, New York.

FIGURE 32 TWO-WAY PLOW

Vee Plow

In areas where moderate drifting may occur, a Vee plow shown in Figure 33 is useful for bucking through the drifts. Typically a Vee plow is mounted on a large four-wheel drive truck, and is used in combination with dual wing plows to keep open areas subject to minor drifting.

Wing Plow

The wing plow (Figure 33) is a versatile piece of equipment, which can be used for pushing back high drifts or the accumulated snow left over from earlier storms along the edge of the road. In tandem it is also used often for plowing light snow on a multi-lane highway. In this operation, the snow collected by the truck's front-mounted two-way plow is caught by the wing plow and pushed back further, thus increasing the width of road cleared in a single pass by one truck. In trucks equipped with one or two wing plows, a second operator is required to operate the wing plow particularly when winging-back accumulated snow in the vicinity of road signs, culverts, and guard rails.

Underbody Scrapers

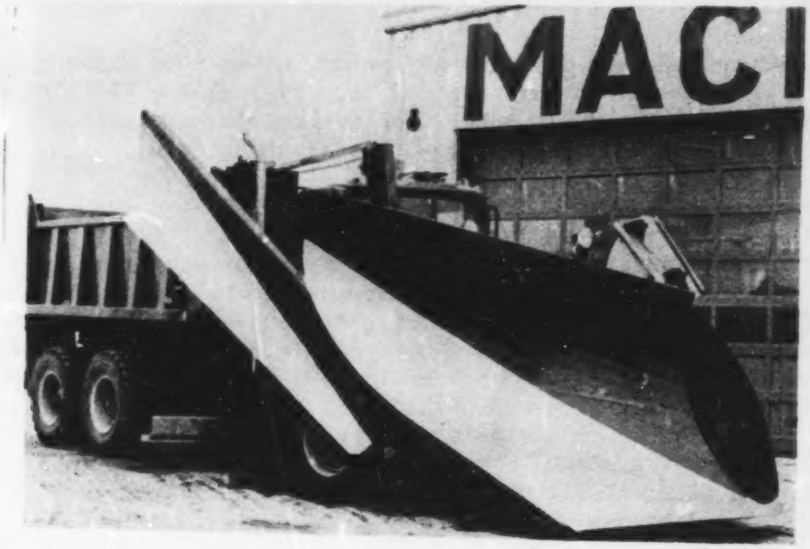
Trucks equipped with underbody scrapers are useful for removal of hard pack snow from roadways (Figure 33). These plows are capable of exerting downward pressure on the cutting edge of the plow and breaking through ice and hard pack under some circumstances. Underbody plows are also useful for removing light accumulations of snow (up to 2 in.). The remote control feature of the angle of the underbody plow is desirable.

Additional Features of Plows

All snow plows must be able to be lifted from the surface of the roadway by the operator through remote control, usually accomplished by a hydraulic control system operated from the cab. In addition, plows should have a mechanism, whereby the moldboard or the whole plow itself trips when it meets an immovable object, such as a manhole cover, frozen rock or a post, thereby minimizing the shock transmitted to the truck and driver and the damage that might be incurred by the plow itself.

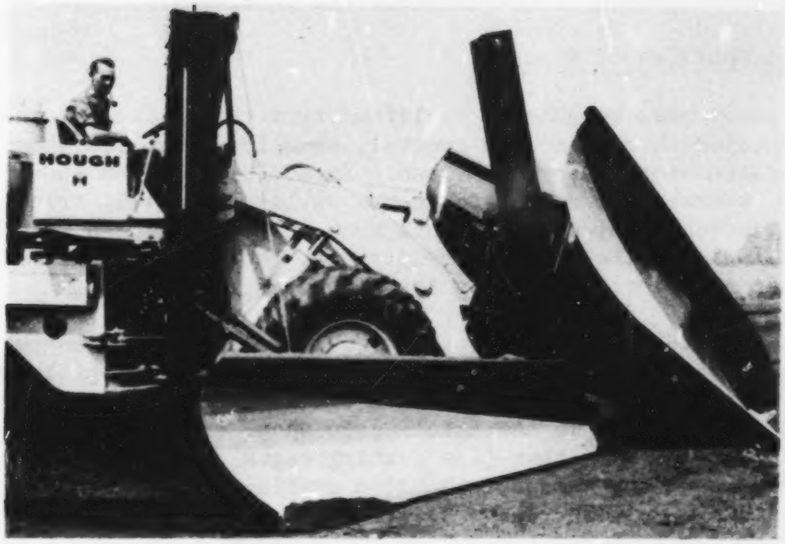
All front-mounted plows must have a hitch firmly attached to the frame of the truck and to which the plow itself can be attached rapidly when needed. A wide variety of hitches are available, many of which are fabricated or modified in the maintenance shops of the various municipalities. Many organizations find that plow cutting edges that have tungsten carbide inserts eliminate the need for changing cutting edges, give far longer service, and are well worth the additional purchase cost.

For areas where the minimum temperature is 28-32°F, rubber cutting edges for snowplows have been used with some success for removing freshly fallen or slushy snows from roads equipped with raised reflectorized traffic markers.[8,9] Even in this temperature range, salt or other chemicals



Courtesy of Frink Sno-Plows, Clayton, New York.

FIGURE 33 VEE PLOW, WING PLOW, AND UNDERBODY SCRAPER ON TANDEM-DRIVE TRUCK



Courtesy of Frink Sno-Plows, Clayton, New York.

FIGURE 34 FRONT-END LOADER EQUIPPED FOR PLOWING

must be used to keep the snow from packing and to produce slushly snow which can be easily plowed. Rubber or polyurethane cutting edges are not useful when the temperatures are below the critical temperature range of 28-32°F and steel or carbide-insert blades are needed to remove the snow.

GRADERS

In some municipalities, road graders that are used during the summer for grading shoulders are used in the winter time for snow-plowing operations. With two axles, single- or four-wheel drive, or three axles with two rear drive, these graders can be equipped with a heavy-duty two-way front-mounted plow. Such a unit is useful for both straight-line operations and for clearing parking lots and other large areas. The easily controlled scraper blade is often the only piece of equipment that is capable of removing hard pack and ice from roadway surfaces.

FRONT-END LOADERS

The rubber-tired, front-end loader is the equipment of choice for handling snow and ice control materials such as sand, salt, and mixtures thereof. The articulated (hinged in the middle) version of this machine provides maximum maneuverability for a given size machine. Such machines can be used year-round for a variety of construction and maintenance tasks.

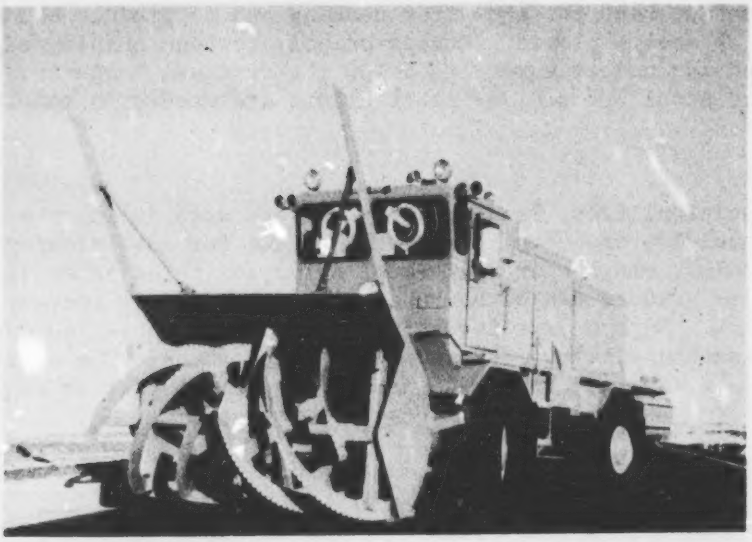
Considerable versatility in a plowing operation is provided when a large front-end loader is equipped for plowing as shown in Figure 34. This unit is capable of maneuvering in very tight quarters, and the articulated model can make a sharp, 90-degree turn, an extremely useful feature for urban snow plowing.

When a front-end loader is provided with two or more different bucket sizes, savings of time and wear on equipment are achieved. A small-volume bucket will prevent overloading of the machine during the summer season, and a larger bucket will increase productivity when salt, sand and snow are being handled during the winter season. For a plowing operation, a machine rated at 2-2.5 yd^3 is preferred. For general loading operations, a machine rated at 1.5 yd^3 and equipped with a 2-yd^3 bucket is preferred.

SNOW BLOWERS

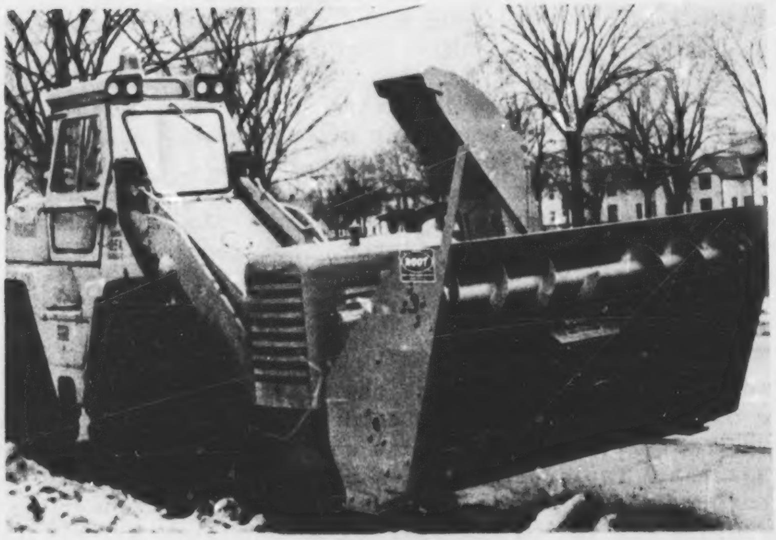
In many instances, snow blowers are the only means whereby roads can be maintained open. These conditions occur in the high mountain passes where heavy snowfalls occur, in areas where heavy drifting is frequent, and in areas where rapid removal of accumulated snow is required, such as on airport runways. For these heavy-duty applications, large snow-blowing machines similar to the ones shown in Figure 35 have been developed. Equipped with two large diesel engines, this unit is capable of casting as much as 3,000 tons of snow per hour a distance up to 125 feet.

For lighter-duty operations, units of smaller capacity are utilized. Smaller units are used for road clearing and for loading trucks when clearing areas (such as downtown areas) in which snow cannot be stored.



Courtesy of American Snoblast Corp., Denver, Colorado.

FIGURE 35 SNOW-BLOWING MACHINE



Courtesy of Root Spring Scraper Co., Kalamazoo, Michigan.

FIGURE 36 FRONT-END LOADER EQUIPPED WITH SNOWBLOWER UNIT

A popular new concept in light-duty snow blowers is the self-powered unit that is attached to the lift forks of a front-end loader as shown in Figure 36. The unit shown has its power unit located immediately behind the augers and blower. Other models, powered by hydrostatic units, have a power unit mounted on the back end of the loader and rely upon heavy-duty hydraulic motors for powering the augers and blowers. A particular advantage of the front-end loader unit is that it can cut down high drifts (snow depths up to 12 feet) by raising the blower unit on the loader arms and cutting into the drift at successively lower levels. Front-end mounted units are made with capacities of up to 1,500 tons per hour and can cast the snow as far as 100 ft.

CHAPTER VI

SPREADER CALIBRATION

Calibration of all chemical spreaders is the most important action that an agency can take to control and reduce the amount of harmful deicing chemicals that enter the environment. Calibration of spreaders not only controls and reduces the amount of material used but it also saves money by providing the desired level of service with less deicing chemicals. The objectives of a thorough calibration program are very accurate knowledge of the amount of chemical delivered by all units at each spreader setting and identification and repair of all spreader units than cannot be controlled within the range of prescribed spreading.

Spreaders should be calibrated annually before the winter season begins. The calibration should be rechecked during the winter if any of the major parts of the hydraulic system are replaced, if the moving mechanical parts of the spreader are damaged or replaced, or if for any reason the spreading rate becomes suspect.

Spreaders should be calibrated not only for the amount of salt dispensed each mile the truck travels but also for the pattern of distribution of material on the road surface.

In this section, two basic ways of calibrating chemical spreaders for the amount per mile traveled are described. One method, a yard calibration, involves measurement of the amount the unit delivers over the complete range of control settings of the spreader. The second, an in-service calibration, is a calculation based on actual spreader operation, i.e., total load delivered over a stretch of road of known length.

YARD CALIBRATION

Spreaders Without Ground-Speed Controllers

The calibration technique described in this section is based primarily on methods developed by the Salt Institute under their Sensible Salting Program, with modifications incorporated by the Michigan Department of State Highways and others. This technique is applicable to hopper-type spreaders and truck-tailgate spreaders, both of which rely upon the rotation of a mechanical element (an auger shaft or flite-chain sprocket shaft) for feeding chemicals and/or abrasive materials from the vehicle to the distribution mechanism of the spreader. Although applicable to hydraulically controlled spreaders, the technique is adaptable also to independently powered spreader units.

Equipment Required

The equipment required for calibration of salt spreaders includes:

Agency ____________

Location ____________

Truck No. ____________

Spreader No. ____________

Gate Setting ____________ (inches)

Salt, Sand, Special Blend ____________ (Circle One)

Size of Load ⑪ ________ (Tons) X 2,000 ____________ (Lbs)

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰	⑱
Control Setting	Auger or Chain-Spreader Speed (RPM)	Discharge Weight (Lb/Rev)	Discharge Rate (Lb/Min) ②×③	Amount Spread (Lb/Mile)						Size of Load (Lbs)	⑪ ÷ ④	Distance for Full Load (Miles)					
				15 mph	20 mph	25 mph	30 mph	35 mph	40 mph			15 mph	20 mph	25 mph	30 mph	35 mph	40 mph
				④ X 4.00	④ X 3.00	④ X 2.40	④ X 2.00	④ X 1.71	④ X 1.50			⑫ ÷ 4.00	⑫ ÷ 3.00	⑫ ÷ 2.40	⑫ ÷ 2.00	⑫ ÷ 1.71	⑫ ÷ 1.50
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

By ____________

Date ____________

Remarks ____________

____

FIGURE 37 CALIBRATION WORKSHEET – SPREADER WITHOUT GROUND-SPEED CONTROLLER

- A scale for weighing the amount of salt. The scale can be a hand-held or platform type and should be capable of weighing quantities between 0 lb and 100 lbs, with a resolution of 2.0 lb. The accuracy of the scale should be verified either by the agency's department of weights and measures or with several calibration weights.

- A means for collecting up to about 100 lb of chemical material (a square yard of canvas with grommets at each corner or a burlap sack). For any collector weighing more than about 0.5 lb, the tare weight should be determined.

- A stop watch or a watch with a second hand for timing shaft revolutions.

- A shaft tachometer (if shaft rotation speed is too fast to follow by counting).

- A means for placing a mark on the end of the auger or flite-chain sprocket shaft. A marking pen, a dob of paint, a file mark or a prick punch mark will do.

- Calibration worksheets like those shown in Figure 37.

- A clipboard or other means for holding calibration worksheets while data are being assembled.

Calibration Procedure

The following procedure is recommended for calibration of spreaders that do not have ground-speed controllers.

1. Clean the shaft end of the auger or flite-chain sprocket shaft. Place an index mark on the end of the shaft so that the number of revolutions per minute can be counted at each dial setting. If the shaft end is not exposed, mark the auger flite sprocket.

2. Remove the spinner disc or bypass the spinner motor with a hydraulic line.

3. With the spreader system running and empty, let the truck idle long enough to warm the hydraulic oil to a normal working temperature.

4. Place a half load of salt in the truck body to put a load on the spreader. This partial load will simulate actual working conditions.

5. Open the throttle so the engine is running at approximately working speed. If the truck is equipped with a tachometer, set the throttle at the engine speed normally used during salting.

6. For hopper-type spreaders, open the gate to the appropriate setting for the type of material for which the spreader is being calibrated (salt, premix of salt and calcium chloride, salt/sand, sand, or other abrasive). Trial and error adjustments may have to be made in the gate opening in order to get the desired spread rate.

7. Fill the spreader auger or conveyor with salt by rotating it a few turns.

8. Set the spinner motor control to its usual level.

9. When the auger is full, place the canvas or the bag under the discharge opening so that all of the salt discharged is caught. Allow the auger or the sprocket to make one full turn at a low setting and collect the salt that is discharged.

10. Weigh the salt, deducting the weight of the canvas square, bag, or other collector. Accuracy is important because this factor is used repeatedly in the calculations. For greater accuracy, repeat step 9 above several times and then take the average weight and enter it in Column 3 of the worksheet (Figure 37). Once the weight per revolution has been established that weight will remain constant throughout the calculating procedure.

11. To determine the number of revolutions per minute (RPM), use a stopwatch or a watch with a second hand; count the number of RPM's of the auger or flite-chain sprocket shaft at each control setting. If necessary, use a hand tachometer. Record these in Column 2 of the worksheet in Figure 37.

Calculations

The worksheet now contains two pieces of data needed for calculation of the amount of salt that will be discharged in 1 min. Multiply Column 2 by Column 3 and enter the result (discharge rate in lb/min) in Column 4.

To complete the calculation, you need to know the number of minutes required for the truck to travel one mile at various road speeds. These are tabulated in Table 7 and shown in Columns 5-10 of the worksheet. To calculate the amount spread per mile when the truck is traveling at 15 mph, multiply Column 4 by the constant shown at the head of Column 5 and enter the result in the proper place. Likewise, to determine the amount spread at 20, 25, 30, 35 and 40 mph multiply Column 4 by the constants at the top of Columns 5-10, respectively, and enter the results in the proper spaces. Perform these calculations for every control setting.

As an illustration of how the table is used, assume, for example, that the auger or flite-chain sprocket discharges 8 lb of salt (Column 3) each time it makes one full revolution at control setting number 3 and that the auger turned 10 times per minute (Column 2). Obviously, the spreader will put out 80 lb per minute at that setting (Column 2 times Column 3 and the result entered in Column 4).

At a speed of 15 mph as shown in Table 7 the truck moves one mile every 4 min. Therefore, 80 lb/min multiplied by 4 min equals 320 lb/mi. This value is entered in Column 5 for control setting number 3. This procedure should be repeated for each control setting and at the various speeds at which the material is spread. Record all data on worksheet (Figure 37).

The next set of calculations determines the distance that the spreader truck will travel for various control settings and vehicle speeds before the complete load is exhausted. These values are useful for checking the calibration and overall health of the spreader. In Column 11 of the calibration worksheet, enter the size of the load in pounds for the material (salt, sand or mixtures thereof). This should be the weight of the material when it is loaded level with the top of the screens or the top of the spreader hopper (provided this does not exceed the vehicle's legal gross weight). This value can be obtained either from the spreader manufacturer or by weighing a truck full of material and entering the amount in the line provided in Column 11. To calculate the time required to empty the spreader for various control settings divide Column 11 by Column 4, and enter the results in Column 12. The miles that a truck will travel at 15 mph before the load is exhausted is determined by division of Column 12 by the constant given at the top of Column 13. Likewise, the miles a truck will travel before its loads are exhausted at 20-40 mph are calculated in Columns 14 through 18, respectively, on the calibration worksheet. Results should be entered in this table to the nearest 0.1 mi.

Table 7 VEHICLE SPEED CONVERSION FOR SPREADER CALIBRATION

Vehicle speed (mph)	Time to travel one mile (min)
10	6.00
15	4.00
20	3.00
25	2.40
30	2.00
35	1.71
40	1.50
45	1.33
50	1.20
55	1.09
60	1.00

Truck Calibration Card

The last step in the calibration of spreaders is transfer of the results of the calculation onto a calibration card, which will be carried in the cab of the truck. This is simply done by copying the data from Columns 1 and 5-8 onto the pounds-per-mile side of the truck card shown in Figure 38. The calibration check data in Columns 13-18 should be transferred onto the miles-traveled-per-load side (the reverse) of the same calibration chart shown in Figure 39.

On the truck calibration cards, color coding is very useful. For example, those calibration values close to the most usually prescribed amount of salt could be indicated in green, those higher than the prescribed ones in red, and those rates lower than the prescribed rate in black. At a quick glance, the operator can tell when he is operating in the proper range.

The additional information called for on the truck calibration card should also be filled in. The calibration of the spreader is now complete, and the calibration worksheet should be placed on file either in the maintenance record for the truck or in the agency's office. The truck calibration card should be placed in a convenient location in the truck so that it is available for quick reference during a storm.

In some agencies, a template is made from a block of wood which has one dimension equal to the gate opening required for straight salt and another dimension equal to the opening required for another material such as sand. This template is often attached to the spreader calibration card.

Spreader With Ground-Speed Controllers

Spreaders with ground-speed controllers are calibrated by the same basic technique outlined in the previous paragraphs, but with several notable additions.

The equipment required in this calibration is the same used for the spreader without ground-speed controllers except for a modified worksheet. In addition, a pulse generator must be utilized for simulation of the truck's ground-speed sensor. It can be one provided by the manufacturer, a low-frequency audio pulse generator capable of 100 cycles per second or whose specification can be provided by the controller manufacturer, or a homemade pulse generator with a standard truck sensor driven by a variable-speed motor and equipped with a tachometer. These pulse generators are based on the fact that all speedometers rotate at 1,000 RPM when the vehicle is moving at 60 mph. Special precautions must be taken if the truck is equipped with a two-speed rear-end axle and does not have a compensated speedometer drive. If this is so, care must be taken to insure that the truck is used only in the rear-end speed setting for which the speedometer is calibrated correctly.

Measurement Procedures

The following procedures are followed for calibration of spreaders equipped with ground-speed controllers.

Spreader Calibration
Pounds per Mile

Material ____________

Gate Opening ____________ Truck No. ____________

Spreader Ident. ____________ Load Size ____________

Control Setting	Amount Spread (Lb/Mile)					
	15 mph	20	25	30	35	40
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Calibration by ____________ Remarks ____________

Date ____________ ____________

FIGURE 38 SPREADER CALIBRATION CARD (FRONT SIDE)
TRUCK WITHOUT GROUND-SPEED CONTROLLER

Spreader Calibration
Miles per Load

Material ____________________

Control Setting	Distance Traveled per Load (Miles)					
	15 mph	20	25	30	35	40
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

FIGURE 39 SPREADER CALIBRATION CARD (REVERSE SIDE)
TRUCK WITHOUT GROUND-SPEED CONTROLLER

1. Disconnect the lead from the truck speed sensor and connect the pulse generator. Set the pulse generator for a speed setting of 30 mph.

2. Clean the shaft end of the auger or flite-chain sprocket shaft. Place an index mark on the end of the shaft so that the number of revolutions it makes per minute can be counted at each control setting. If the sprocket shaft end is not exposed, mark the auger flite sprocket.

3. Remove the spinner disc or bypass the spinner motor with a hydraulic line.

4. With the spreader system running and empty, let the truck idle long enough to warm the hydraulic oil to normal working temperature.

5. Place a half load of salt in the truck body to put a load on the spreader. This partial load will simulate actual working conditions.

6. For hopper-type spreaders, open the gate to the appropriate setting for the type of material for which the spreader is being calibrated (salt, premix of salt and calcium chloride, salt/sand, sand or other abrasive). Trial and error adjustments may have to be made in the gate in order to get the desired spread rate.

7. Open the throttle so that the truck engine is running at approximately working speed. If the truck is equipped with a tachometer, set the throttle at the engine speed normally used when salting.

8. Set the ground-speed controller at its lowest setting and activate the spreader auger or conveyer to fill it by allowing it to rotate a few turns.

9. Set the spinner motor control to its usual level.

10. When the auger is full, place the canvas or bag under the discharge opening so that all of the salt discharge is caught. Allow the auger or the sprocket to make one full turn at this low setting of the ground-speed controller and collect all the salt that is discharged.

11. Weigh the salt, deducting the tare weight of the canvas square, bag or other collector. Accuracy is important because this factor is used repeatedly in the calculations. For greater accuracy, repeat step 10 above several times and then take the average weight and enter it in Column 3 of the worksheet (Figure 40). Once the weight per

Agency ____________________

Location ____________________

Controller Type ____________________

Truck No. ____________________

Spreader No. ____________________

Gate Setting ____________________ (inches)

Salt, Sand, Special Blend ____________ (Circle One)

Size of Load ________ (Tons) X 2,000 ________ (Lbs)

Calibration Speed or Pulse Setting ________ (mph)

Minutes to Travel One Mile at Above Calibration Speed ⑤ ______ (Min/Mile)

①	②	③	④	⑤	⑥	⑦	⑧
Control Setting	Auger or Chain Sprocket Speed (RPM)	Discharge Weight (Lb/Rev)	Discharge Rate (Lb/Min) ②×③	Minutes per Mile (Min/Mile)	Quantity Spread ④×⑤ (Lbs/Mile)	Size of Load (Lbs)	Distance for Full Load ⑦÷⑥ (Miles)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Speed (mph)	Time to go One Mile (Minutes)	Pulses for 6-Pole Sensor
10	6.00	1,000
15	4.00	1,500
20	3.00	2,000
25	2.40	2,500
30	2.00	3,000
35	1.71	3,500
40	1.50	4,000
45	1.33	4,500
50	1.20	5,000
55	1.09	5,500
60	1.00	6,000

By ____________

Date ____________

Remarks ____

____

FIGURE 40 CALIBRATION WORKSHEET – SPREADER WITH GROUND-SPEED CONTROLLER

revolution has been established, that weight will remain constant throughout the calculation procedures.

12. To determine the number of revolutions per minute (RPM) for the shaft, use a stopwatch or a watch with a second hand and count the number of RPM's of the auger or flite-chain sprocket shaft at each control setting. If necessary, use a hand tachometer. Record these on the worksheet shown in Figure 40.

Calculations - All of the data are now available for calculating the amount of salt that will be discharged in 1 min. This is done by multiplying Column 2 by Column 3 and entering the result (discharge rate in lb/min) in Column 4.

To complete the calculation you need to know the minutes required to travel one mile at the calibration speed or at the pulse-setting rate. These values are tabulated on the worksheet. Assume that the calibration speed is 30 miles per hour; therefore. the time required for the vehicle to travel 1 mile is 2 min. This value is constant throughout the remainder of the calculation and is independent of control setting, therefore, 2.0 should be entered in Column 5 of the worksheet. Pick a calibration speed consistent with regular spreader operations.

Because it is independent of the truck speed, the quantity spread is easily calculated by multiplication of Column 4 by Column 5 to give the quantity spread in pounds per mile for the particular control setting. Enter the results in Column 6 and repeat for each control setting, using the same values for Column 5.

As an illustration of how the table is used, assume, for example, that the auger of flite-chain sprocket discharges 8 lb of salt (Column 3) each time it takes one full revolution at control setting number 4 and that the auger turns 15 times per minute (Column 2). Obviously, the spreader will put out 120 lb/min at that setting (Column 2 x Column 3 and the results entered into Column 4). Since the calibration speed is 30 mph and the time to travel 1 mile is 2.0 min (Column 5), the quantity spread per mile is the product of Column 4 x Column 5 (120 x 2.0 = 240 lb/mi). This calculation procedure should be repeated for each control setting and all data should be recorded on the worksheet.

The next set of calculations determines the distance that the spreader truck will travel for the various control settings before the complete load has been exhausted. These values are useful for checking the calibration and overall health of the spreader. In Column 7 of the calibration worksheet, enter the size of the load (lb) for the material (salt, sand, mixtures, or other abrasives). This weight should be for the material when loaded level with the top of the screens or the top of the spreader hopper. This value can be obtained either from the manufacturer or by weighing a truck full of material and entering the amount in the line provided in Column 7. This value is constant and independent of the control setting. To determine the distance that a truck can travel at a given control setting before the load is exhausted divide Column 7 by Column 6 and enter the results in Column 8.

Calibration card for trucks - The last step in this calibration of spreaders is transfer of the results of the calculations onto a calibration card that is carried in the cab of the truck. This is simply done by copying the data from Columns 1, 6, and 8 of the worksheet onto the truck calibration card shown in Figure 41.

IN-SERVICE CALIBRATION

An in-service calibration is an excellent and simple way to determine how much material a spreader actually discharges. The following technique is especially useful for calibrating ground-speed controlled units. The technique is valid only for the controller setting used at the time of calibration and, calibration at both higher and lower controller settings, while possible by this technique, may either spread too much material or not enough material to do the job properly.

No equipment is required for this type of calibration. The technique requires, however, that the truck have a reasonably accurate odometer (± 5%); odometer accuracy can be determined by checking the truck against a measured mile. The technique also requires the knowledge of the capacity of the spreader when it is loaded with material up to the top of the screen or level with the top of the spreader hopper.

The technique requires that the spreader be set to the control setting near the desired range. The driver then spreads salt over the prescribed route and measures how far the truck goes before the load is exhausted. For trucks without ground-speed controllers, this technique requires that the driver maintain the truck speed constant at or near the desired spreader amount setting. Data for this type of calibration are entered in the calculation worksheet shown in Figure 42. To calculate the amount of material spread per mile divide Column 2 by Column 4 and enter the result in Column 5 of the worksheet. Data from this calculation worksheet should be entered on a truck calibration chart to be placed in the cab of the truck.

In-Service Check of Spreader Performance

The accuracy of calibration and the general overall health of a spreader can be checked periodically by the driver using the data from the truck calibration tables about how far a truck should travel on a full load under prescribed controller setting and vehicle speed (spreader without ground-speed controller). If for instance, his calibration chart says that the truck should go 15.5 miles at a controller setting of 4 and a speed of 30 miles per hour and the truck driver finds that he is going only 10 miles before the load is exhausted, then the driver knows that there is something wrong with the spreader and it should be remedied.

Spreader Calibration

Gate Opening ____________________ Truck No. ____________________

Spreader Ident. ____________________ Load Size ____________________

Calibration Speed or Pulse Setting ____________________

Control Setting	Amount Spread (Lb/Mile)	Distance Per Load (Miles)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Calibration by ____________________ Remarks ____________________

Date ____________________ ____________________

FIGURE 41 SPREADER CALIBRATION CARD FOR TRUCK WITH GROUND-SPEED CONTROLLER

Agency ____________ Truck No. ____________ Gate Setting ____________ (in.)

Location ____________ Spreader Ident. ____________ Material ____________

① Controller Setting	② Load (Lbs)	③ Truck Speed (mph)	④ Distance Traveled With Load (Miles)	⑤ Amount of Material ②÷④ (Lb/Mile)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Calibration by ____________ Date ____________ Remarks ____________

FIGURE 42 CALCULATION WORKSHEET FOR IN-SERVICE CALIBRATION

Table 8 TABLE FOR CHECKING SPREADER PERFORMANCE

Prescribed Spread Rate (lb/mile)	Miles traveled for full load									
	1.5 (tons)	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6
100	30	40	50	60	70	80	90	100	110	120
125	24	32	40	48	56	64	72	80	88	96
150	20	26.7	33.3	40	46.7	53.3	60	66.7	73.3	80
175	17.1	22.8	28.6	34.3	40	45.7	51.4	57.1	62.8	68.6
200	15	20	25	30	35	40	45	50	55	60
225	13.3	17.8	22.2	26.7	31.1	35.5	40	44.4	48.9	53.3
250	12	16	20	24	28	32	36	40	44	48
275	10.9	14.5	18.2	21.8	25.4	29.1	32.7	36.4	40	43.6
300	10	13.3	16.6	20	23.3	26.7	30	33.3	36.7	40
325	9.2	12.3	15.4	18.5	21.5	24.6	27.7	30.8	33.8	36.9
350	8.6	11.4	14.2	17.1	20	22.8	25.7	28.6	31.4	34.3
375	8.0	10.6	13.3	16	18.7	21.3	24	26.7	29.3	32
400	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30
425	7.0	9.4	11.8	14.1	16.5	18.8	21.2	23.5	25.9	28.2
450	6.7	8.9	11.1	13.3	15.6	17.8	20	22.2	24.4	26.7
475	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21	23.2	25.3
500	6.0	8.0	10	12	14	16	18	20	22	24
600	5.0	6.7	8.3	10	11.7	13.3	15	16.7	18.3	20
700	4.3	5.7	7.1	8.6	10	11.4	12.8	14.3	15.7	17.1
800	3.8	5.0	6.3	7.5	8.7	10	11.3	12.5	13.7	15
900	3.3	4.4	5.5	6.7	7.8	8.9	10	11.1	12.2	13.3
1000	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10	11	12

Even for spreaders that are not calibrated, the rule-of-thumb figures in Table 8 are an indication of how far a truck should go with a given load of salt for a prescribed spreading rate.

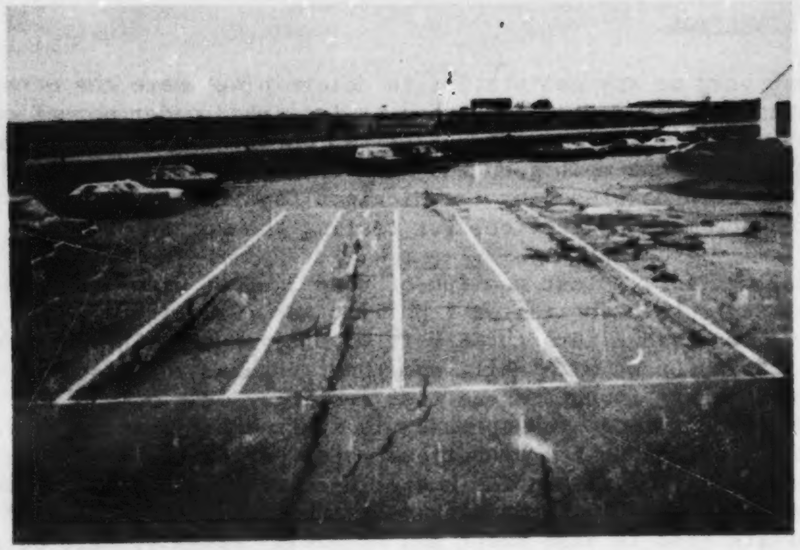
As an example, if a spreading rate of 250 lb per mile is prescribed, a truck with 4 tons of salt should be able to travel 32 miles before its load is exhausted.

Table 8 can also be used to determine how much material per mile is actually being spread. For instance, suppose the truck has a load of 5 tons of salt and that it travels only 20 miles before the load is exhausted. The spreading rate from Table 8 is 500 lb/mi.

PATTERN CALIBRATION

An important part of any calibration is determining where the material finally comes to rest on the road when it is spread under normal operating conditions. Ideally, to be most effective, chemicals must be placed where they will do the most good and with a minimum amount of loss. A technique has been developed by the Michigan Department of State Highways Maintenance Methods Section, for testing the spread pattern.

For this calibration, a test section of road 24-feet wide and 100-feet long is painted onto a section of a parking lot (see Figure 43). This test section is divided into three 8-ft wide segments. The spreader to be calibrated is loaded with salt, and the truck is brought up to calibration speed before it enters the test section. Just before the truck reaches the test section, the spreader is started and salt is spread over the test pattern at the prescribed rate. After the truck passes, the salt that is lying within the center 8-ft wide lane of the road is swept up and weighed. The remaining salt in the two adjacent 8-ft wide sections of the road is also swept and weighed. Finally, salt outside of the 24-ft wide test section is swept and weighed. The sum of the three amounts of salt collected is the total amount spread on the test section. The percentage of material falling within the center 8-ft band is determined by division of the weight of material in the center 8-ft band by the total. The percentage of salt falling on the road is the sum of the material in the 8-ft lane and the two side lanes divided by the total. A truck with the desired spreading pattern will leave at least 75% of the salt within the center 8-ft band, and 95% of the salt will be within the 24-ft band.



Courtesy of State of Michigan Department of Highways.

FIGURE 43 TEST ROAD SECTION FOR CALIBRATION OF SPREAD PATTERN

PART FIVE: PUBLIC INVOLVEMENT

CHAPTER VII

CITIZEN EDUCATION AND COOPERATION

INTRODUCTION

Previous sections of this manual, as well ad the Manual for Deicing Chemicals: Storage and Handling, have emphasized the mechanical tools needed by maintenance managers in handling deicing chemicals properly. This Part discusses other kinds of tools, not mechanical but just as important in helping maintenance officials.

Three broad strategies exist for improving the use of deicing chemicals. The first might be termed the technical appraoch; this has several components, such as improving equipment, improving the management of chemicals through such devices as reporting systems, and simply reducing the use of and reliance upon chemicals. Most discussion about winter maintenance, including Parts Three through Five of this manual, concentrate upon the mechanical and technical tools that maintenance officials can control most easily, such as trucks, plows, road crews, and road salt.

But these tools affect only part of the total problem or system. It can be described as "moving people and goods during bad winter weather". This system includes or is affected by many components, including roads, cars, winter driving equipment on cars, weather and weather forecasting, snow-fighting organizations, and travelers and especially drivers.

The second approach is legal or coercive. Legislators, officials of government agencies, and citizens' environmental groups seeking to reduce salt usage have recently turned to it as a means to define limits within which highway officials may operate. Part One describes the several components of the legal and regulatory framework, which is becoming more restrictive.

The third approach is educational or persuasive. It has been the least used to date, perhaps because it focuses on the majority of participants in our system of moving people from here to there--those who drive and ride over roads and highways. Clearly, their behavior in demanding services influences significantly how well or poorly road crews can do their work.

None of these three approaches can be used alone with success. Each can and should support the others. All are needed for a successful program of reducing reliance on chemicals.

This part of the manual addresses the third approach. Although maintenance managers may not greatly influence (or feel that they can influence) drivers and behavior, they should not ignore these participants in winter transport system. The following discussion assembles and presents ways in which managers can develop and enlist the support of drivers and citizens, especially influential ones, for their wintertime maintenance policies.

Our sources for this discussion are several. Here, as in other Parts, we are not seeking to develop an impossible ideal; instead, we are reporting on the best current practices as we have found them being used by operating officials. Examples were gathered during field observation trips, from many talks with highway officials as well as environmental educators, and from the literature. Especially useful comments came from a panel on citizen cooperation which was part of the 13th Annual North American Snow Conference, in New York City, 1973.

Many techniques for citizen education and cooperation are potentially available. We have treated separately, in Part One, the legal framework, which serves both an educational as well as a coercive function. A manager probably cannot and should not use all of the techniques to be described. Instead, he must choose those most suited to the character of his local situation, and then adapt them to its special needs; in the process, he will probably improve these techniques in his own ways. The choice of techniques will vary, for example, according to the level of concern and knowledge of citizens in his community or jurisdiction.

Some officials may feel that citizen cooperation is nice but not absolutely necessary. Others may feel that worrying about it is not really part of the maintenance manager's job. The assumption underlying the following is that citizen cooperation is not only nice, but also useful and productive. For example, citizen attitudes can be crucial in influencing how legislators, whether they are town meeting members, city councilors, or state representatives, vote on requests by the department of public works for more funds for building salt storage sheds or buying improved spreaders. For another example, highway crews in communities where citizens make a conscious effort to stay off roads during snow removal operations can accomplish their tasks far more easily than their colleagues in communities where citizens demand unreasonable levels and speed of service.

Of course, it is difficult for maintenance managers to communicate with all citizen drivers individually. Instead, they must work through a variety of organizations, both formal and informal, both governmental and voluntary. Formal governmental organizations, such as police departments and conservation commissions, are obviously key channels for communication and education. Private voluntary organizations, such as the American Automobile Association and the League of Women Voters, offer much potential for helping managers. A 1972 pamphlet by the U.S. Environmental Protection Agency, Citizen Action Can Get Results, describes that potential well:

> "Voluntary citizen organizations have long been part of the way of life in the United States. Individuals with common interests--social, civic, cultural, religious, political, business, professional, etc.--have come together in clubs, societies, associations and groups to share these common

> interests, exchange experiences and pursue mutual goals. Thousands of groups exist, among them now are at least 3,000 conservation and environmental organizations. This number includes approximately 250 national and regional groups and some 400 state organizations. On the local community level, there are approximately 2,500 organizations of individuals concerned about one or more conservation or environmental problems. In addition, there are uncounted civic, church, labor, business, youth, school and women's groups which devote at least some of their efforts to environmental problems."
>
> "Environmental organizations vary in size and range of activity. Some employ professional staffs. Some, especially on the local level, operate with volunteers. Some are concerned with a single issue, some with any and all environmental problems. While the scope and degree of their efforts vary, in total they engage in a multitude of activities on behalf of a better environment. They work for water pollution control, cleaner air, noise control, better methods of solid waste disposal, conservation of natural areas, preservation of wildlife, population control, transportation reform, pesticide control and sound resource management. Some are primarily educational groups. They educate their members and the general public through their publications. Others engage in legislative activities, stimulating their members and the public to make their pro-environmental views known to elected and appointed public officials. Some conduct meetings, workshops and seminars, and engage in political action for or against candidates. Some take legal action to assure that government and industry abide by environmental protection laws and regulations. Directly or indirectly, they bring pressure on government at all levels to enact and implement environmental protection laws and regulations."
>
> "In sum, citizen organizations in the environmental field serve as active, articulate voices of a public which has become increasingly concerned about environmental quality. They fulfill a watchdog role. And they exert a pro-environmental influence on public opinion, on the press, on industry and on government."

Examples of effective voluntary action by citizens on environmental problems are many. Those following suggest how effectively even a few citizens, armed with determination and knowledge, can influence major governmental actions. They also suggest that citizen concern and energy can be enlisted by officials in support of important governmental programs.

- Groups of concerned citizens have won battles against proposed highways which would have destroyed historic and scenic natural areas.

- A Maryland scientist worked after hours with school children in his community to mount a community-wide campaign which led to enactment of the first municipal law banning non-returnable soft drink and beer containers.

- Citizens in many cities have established recycling centers, where waste bottles, cans and newspapers are collected for shipment to reprocessing plants for reclamation and reuse.

- A Massachusetts citizens committee aroused public awareness of the environmental damage caused by deicing salts, and helped to write and pass that state's new legislation to regulate salt use.

- A citizen advisory committee in a Massachusetts town successfully supported efforts by the DPW to obtain improved snowfighting equipment.

We have assembled in an appendix the names, addresses, and descriptions of various organizations--private and governmental, national and state--having resources which maintenance managers should explore in light of their specific local situations. To identify quickly names of key persons in local voluntary private organizations, whether or not affiliated with national organizations, maintenance managers should start by contacting the environmental chairman of their local League of Women Voters or a similar well-established group; it customarily tracks such issues and the critical actors involved in them.

The general ideal of the manager influencing the habits of the driving public is, we recognize, not especially useful. He is only one, while they are many. Even with ample time and budget, he and his organization could not hope, except perhaps in small towns, to communicate with all drivers effectively. Instead, he must use a variety of natural and potential channels, both to publish his policies and to receive reactions and opinions from citizens. Figure 44 attempts to depict schematically the organizational context or world within which the maintenance manager works. He and his immediate aides occupy its center. The surrounding concentric circles display the persons and organizations, both governmental and private, with whom they have customary links; those within the road or highway department and in other government agencies naturally occupy the nearest circles. The figure suggests that the maintenance manager should consciously expand his relationships to groups in the circle farthest from the center.

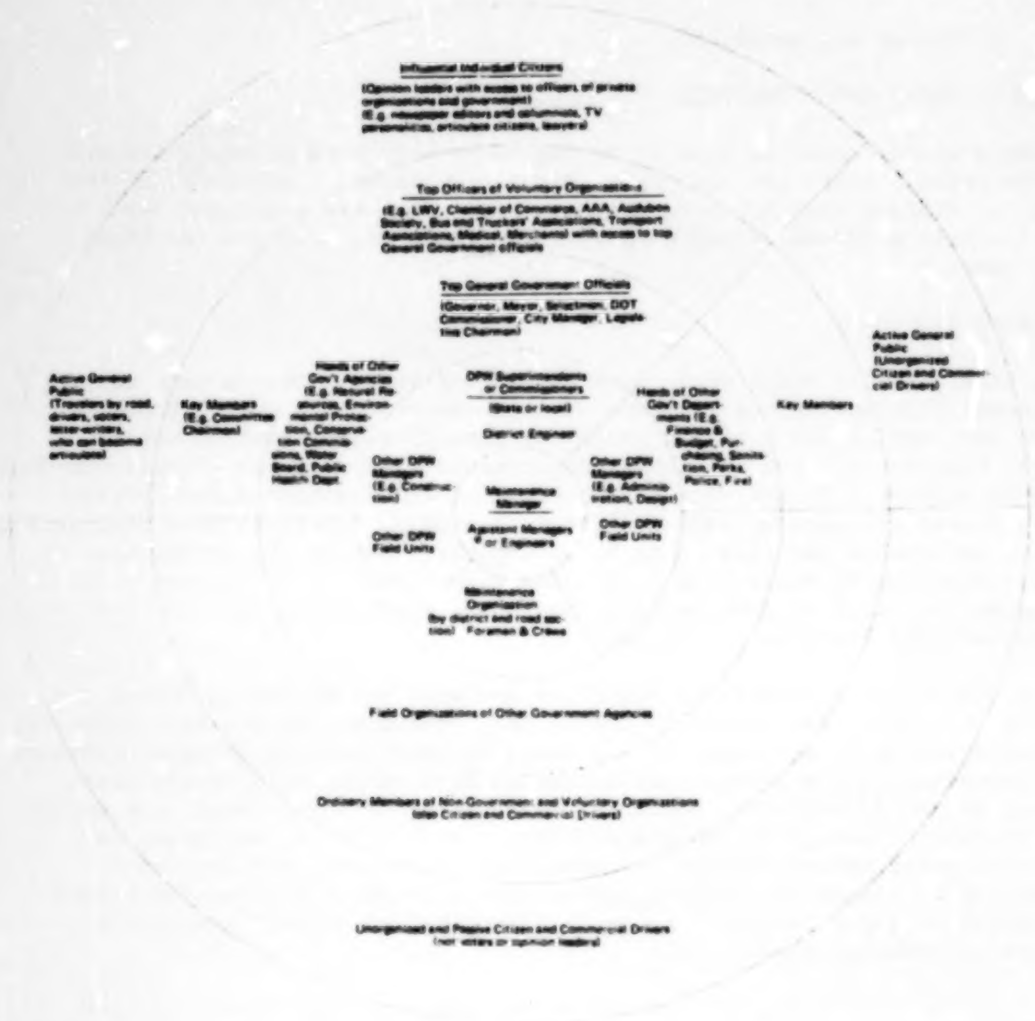

Influential Individual Citizens
(Opinion leaders with access to officers of private organizations and government)
(E.g. newspaper editors and columnists, TV personalities, articulate citizens, lawyers)
Top Officers of Voluntary Organizations
(E.g. LWV, Chamber of Commerce, AAA, Audubon Society, Bus and Truckers' Associations, Transport Associations, Medical, Merchants) with access to top General Government officials
Top General Government Officials
(Governor, Mayor, Selectmen, DOT Commissioner, City Manager, Legislative Chairman)
Active General Public (Travelers by road, drivers, voters, letter-writers, who can become articulate)
Key Members (E.g. Committee Chairmen)
Heads of Other Gov't Agencies (E.g. Natural Resources, Environmental Protection, Conservation Commissions, Water Board, Public Health Dept.
DPW Superintendents or Commissioners
(State or local)
District Engineer
Heads of Other Gov't Departments (E.g. Finance & Budget, Purchasing, Sanitation, Parks, Police, Fire)
Key Members
Active General Public (Unorganized Citizen and Commercial Drivers)
Other DPW Managers (E.g. Construction)
Maintenance Manager
Other DPW Managers (E.g. Administration, Design)
Other DPW Field Units
Assistant Managers or Engineers
Other DPW Field Units
Maintenance Organization (by district and road section) Foremen & Crews
Field Organizations of Other Government Agencies
Ordinary Members of Non-Government and Voluntary Organizations (also Citizen and Commercial Drivers)
Unorganized and Passive Citizen and Commercial Drivers (not voters or opinion leaders)

FIGURE 44 THE MAINTENANCE MANAGER'S WORLD

The following three sections discuss

- General goals and principles of a citizen education program,
- Specific tools and techniques, and
- Themes and messages.

GENERAL GOALS AND PRINCIPLES

There are many possible ways of trying to develop citizen education and cooperation. There are also many possible messages. Therefore, at the risk of stating what may seem obvious, some ideas are suggested here that should guide maintenance managers in designing programs for their own needs.

Develop Awareness

The first step in every environmental problem is to gather a base of relevant information and to share it with everyone affected. It has been easy during the past few years for concerned conservationists to point fingers of blame at highway departments when evidence of environmental injury appears. To the extent that departments of public works (DPWs) have abused reliance on salt and other chemicals, sometimes even disregarding their own stated policies, this blame is just. But to the extent that departments have merely been responding effectively to widespread citizen demands for service, when everyone was unaware of the delayed adverse injuries, the blame is misplaced.

When the use of chemicals to fight ice and snow was spreading during the 1950s and 1960s, few people in the highway community, in the salt industry, among scientists, and least of all among ordinary citizen drivers--considered or recognized the potential environmental harm which would result years later as accumulation of chemicals built up in the environment; the method of systematic search for unintended future side effects, now known as environmental impact studies or technology assessment, had not yet developed. Almost everyone applauded chemicals for the convenience they provided during wintertime, and most if not all of us were simply not aware of troubles ahead.

As citizens (including the police) became aware of the convenience and benefits of salting, they naturally urged DPWs to use it. Only later and gradually did we become aware of its delayed costs, in the forms of rusting automobiles, dying vegetation, and contaminated drinking water supplies. It will naturally require some time for citizens to become generally aware of the conflicting requirements now placed upon highway maintenance officials - for clearing roads and for minimizing harm to the environment. Until that awareness becomes widespread, highway officials will continue to receive unreasonable demands for service, which will make their wintertime work both unpleasant and difficult.

Therefore, the first purpose of an education and cooperation program must be to communicate to citizens who travel the roads, both maintenance workers and the traveling public, basic information about the problem facing the maintenance manager.

Inform Drivers About Maintenance Needs and Policies

In addition to creating general awareness, DPWs need to issue clear guidelines or policies governing use of chemicals. They must also communicate these policies to both their own workers and the traveling public. Road crews can accomplish their work more easily and efficiently if drivers cooperate during storms, by postponing trips, driving wisely, not harassing road crews, and so on. Clear statements of policy can have a threefold impact: (1) help maintenance crews in knowing when their jobs are done properly, (2) inform police officers about what road crews can and should do, and (3) guide the public in knowing what levels of service to expect.

Show Your Concern

Some critics seem to believe that maintenance officials and workers are not concerned about the negative side effects of their snow-fighting practices. This impression is generally wrong. Maintenance men are citizens, too, who want to enjoy the benefits of healthy trees and safe water. But their concern should be apparent. Citizen critics are more likely to sympathize with the problems of maintenance men if they realize that DPWs are not hostile, defensive, or unwilling to consider reasonable questions posed by citizens. In the next section, we report a number of ways in which DPWs have made their concern apparent, and have thus made their task easier.

Show Your Problems to Citizens

Few citizens have occasion to learn about the difficult problems which face maintenance men every winter--unpredictable weather, tight budgets, and conflicting demands from the public. Few, therefore, realize the complex judgments which maintenance managers must make, concerning such variables as use of contractors, balancing budgets, safety of their men, efficient use of their equipment, responsible use of chemicals, responsiveness to competing pressures from the public, and so on. So, few citizens realize that reducing reliance on chemicals is by no means a simple matter. Citizen drivers cannot learn everything about wintertime maintenance. But they can rather easily learn the main difficulties facing maintenance men. DPWs can take specific steps to educate citizens about their work--including the cooperative role which citizen drivers can play.

Long-range Education is Important, Too

Everyone naturally acts to solve the most insistent and immediate problems, such as influential officials who complain about services in particular places. But some attention should be given to educating the drivers of tomorrow. Adult drivers may be fixed in their attitudes, have little time to learn, and recall the good old days of always-bare roads. But teenagers learning how to drive have more time to learn, more incentive, and perhaps attitudes more sympathetic to environmental concerns. Attitudes and practices do not change overnight. Reliance upon chemicals developed only gradually during the 1950s and 1960s. Awareness of their side effects can spread only gradually, too. So, the time and funds needed to educate teenagers and young adults are better long-term investments than those required for older drivers. Moreover, teenagers can contribute significantly to the education of their parents and other adults. Finally, schools, especially driver education courses, offer an efficient way of reaching this important sector of the driving public.

Don't Wait, Initiate

Government officials who wait in ignorance until complaints from the public reveal a problem are likely to react defensively, too late, and with too little information. Officials should, therefore, take the initiative in educating citizen drivers, using the press and radio media as well as other techniques described in the next section. Some experienced maintenance officials have commented that the maintenance community does not use the media enough. In short, one of the maintenance manager's jobs is to educate citizen drivers. Moreover, he should, for his own sake, do so regularly and actively.

Know the Relevant Facts

This may seem obvious and presumptuous. But experience during the past few years suggest that too few maintenance officials were sufficiently aware of the environmental consequences of their chemical policy, or indeed of actual practices in their own organizations. One problem was that salt was not just used, but abused. Most citizens do not know the exact application rates prescribed by DPW maintenance manuals. But keen observers recognized instinctively that trucks were often spreading more than was required by conditions. And they were right. Random field observations and analysis of statistics revealed that trucks were often spreading twice (or more) salt than specified by the DPW's own maintenance policies. Then, simply by recording more accurately the amounts of salt spread, and without special efforts to calibrate spreaders or change policies, highway departments reduced salt usage by 20% or 30%. In short, maintenance managers were not controlling their own operations by their own standards; hence, they were vulnerable to outside criticism.

One district maintenance manager reported the benefits of knowing the relevant facts. When public complaints mounted, district officials found themselves on the defensive and unable to respond confidently, because they lacked detailed and documented records of how much salt they had spread under what weather and road conditions. In self-protection, they developed a system for recording each truck load and for monitoring by managers of overall usage. To their surprise, they discovered that they were using more salt than planned or expected. Moreover, their new recording system resulted in the reduction of usage by about 26%. The accumulating data allowed the district managers to identify problems and develop solutions. Several years later, they had improved service, reduced salt usage, learned how to respond to citizen complaints with facts rather than emotions, and reported this valuable experience to their colleagues elsewhere. Moreover, the number of complaints dropped sharply.[10]

Work Through Others

The maintenance manager cannot educate the public by himself. He should, therefore, consciously enlist the aid of many others, both officials and citizen leaders who are suggested in Figure 44. Many organizations, can offer significant resources, which would probably cost only the exercise of ingenuity and diplomacy.

Enlist Support from Your Bosses

Although this principle is really part of "work through others", above, it merits separate mention because of its importance. Maintenance leaders need support from their bosses for many reasons. Concerning snow and ice control, the chain of command is the channel through which the most important pressures arrive, for example, when public groups complain directly to the Chief Engineer, the DOT Commissioner, the Mayor, or even the Governor. These pressures naturally influence the degree of support (or criticism) the Maintenance Department receives from higher officials. Common sense dictates, therefore, that maintenance managers should enlist their superiors in their campaign to develop public education and cooperation. Your boss can be part of your problem, insofar as he represents pressures from the driving public; but he can also be turned into part of the solution, helping to cope with those outside pressures. In other words, your several bosses in the chain of command can serve as lightning rods. But they can do so only if they understand and agree with your winter maintenance policies. This you must help them do.

Enlist Citizen Support, Too

Similarly, citizen groups should be changed from part of your problem into part of your solution. Individual citizen and citizen groups that devote enough time and energy to complain are thus signaling their interest in your work. These energies can, with some patience and skill, often be turned into an asset. The next section suggests how.

SPECIFIC TOOLS AND TECHNIQUES

In this section many techniques are reported. Some are useful for towns and small cities, while others are suited only to state-level operations. We do not classify them here, but leave readers to select those most appropriate to their special conditions, for example, their available budget. Furthermore, techniques must be selected also to suit the character of the audience, which may be knowledgeable about the subject of snow and ice control or may be ignorant.

The techniques are presented according to three categories:

- Those that give or publish information to the traveling public,
- Those that get or receive information from highway and road users,
- Those that allow or encourage the exchange of information between the Maintenance Department and its public.

These techniques are listed by title in Figure 45 and then described below.

Information-Giving Techniques

Speeches and Public Appearances-

Frequently during the past several years, highway maintenance officials have been requested or required to appear before public bodies to explain their wintertime policies. The occasions have included panel discussions of highway associations, testimony before legislative commissions or committees, meetings requested by representatives of private environmental organizations, discussions in the Highway Research Board (now Transportation Research Board) of the National Academy of Sciences, and perhaps even appearances on radio and television interview shows. Such public and quasi-public appearances are perhaps relatively new in the experience of maintenance engineers, especially those that occur as the result of pressure and criticism. But they can be used as forums for citizen education. Indeed, appearances should be sought every year, as a matter of routine, in order to explain policies and practices.

Public appearances of course require time and energy, and may thus seem an added burden. Maintenance managers, however, can benefit from them in several ways. They offer opportunities for explaining their policies. They give operating maintenance officials opportunities to show their concern for environmental quality and to explain the difficulties they face. The comments and questions raised by citizens during such meetings can give managers valuable information about public attitudes and knowledge, or lack of knowledge; such information or "feedback" can guide managers in adjusting programs, as well as in educational efforts. It also helps

	Information-Giving Techniques	Information-Getting Techniques	Exchange or Interaction Techniques
EXAMPLES OF ACTIONS:	Speeches and Public Appearances Press Releases Letters to Key Persons and Groups Pamphlets and Fliers Posters and Exhibits Answering Telephone Inquiries Signs on Roads and Highways	Complaints Scan the press Surveys Public hearings	Citizen Workshops Citizen Advisory Boards Town Meetings or City Council Sessions Informal community meetings Invite citizen leaders to observe storm operations Invite environmentalists to take part in fall training session
EXAMPLES OF RESULTS:	Improved citizen understanding of: • negative impacts of over-salting • policies and procedures of highway snow maintenance • maintenance technology and its limitations • needs for driver cooperation	Improved highway maintenance department understanding of: • citizen attitudes and expectations • citizen reactions to existing practices and procedures • areas perceived by citizens as environmentally sensitive.	New agreements on how much salt should be used and where salt should be stored. New policies on which roads should be salted and with which levels of service. Change of attitude on policy, procedures, and associated costs, e.g., citizen appreciation of maintenance man's difficult job, department's appreciation of citizen concern, etc. Agreements about monitoring program. Mapping of environmentally sensitive areas. Citizen support for more maintenance money in DPW budget.

FIGURE 45 SUMMARY OF TECHNIQUES FOR DEVELOPING CITIZEN COOPERATION

managers to inform their own maintenance workers about how their efforts are viewed by the driving public. In short, one of any manager's many responsibilities is to conduct relationships between his organization and the outside world, which includes several kinds of publics, as Figure 44 suggests.

The prospect of making public appearances regularly or annually may seem too great a burden. A manager may feel that it is enough to publish his policies only once. This is wrong, however, for several reasons. Local conditions change, for example, as new roads are opened or new traffic patterns emerge. Maintenance policies will naturally change from year to year as new equipment is purchased, ideas are developed, or chemicals are tried. Perhaps most important, the audience of citizen drivers keeps changing, as new people move into the community, new drivers are licensed, and new people become active in organizations. Finally, educators have learned that once is not enough; lessons must be repeated several times before they sink in. Therefore, citizen education is a continuing job. Opportunities for speaking are potentially many. Energetic managers should seek them out, rather than merely waiting for invitations when controversy erupts.

It may seem that each meeting will require special and time-consuming preparations. This will be true, of course, for the first one or two. But thereafter, the manager's message will be well organized and constant. He will merely need to adjust his emphasis slightly to suit the character of his audience. Of course, a program of public appearances assumes that the manager has already developed a clear set of policies that he needs to make public. These policies become his message. Its form and emphasis varies according to whether he is talking to his boss, legislators, other government departments, or ordinary drivers--some of the many publics which make up the manager's world. But for all of them, the basic message remains the same. Typical occasions are listed below, and your community will probably have others as well.

High School Driver Education Classes
Town Meetings or City Council Meetings
Conservation Commission Meetings
State Legislative Hearings
Civic and Environmental Groups
Monthly or Annual Meetings of Conservation
Associations, Driver Associations (AAA, ALA)
Local and Regional Transportation Groups, etc.
(Typical organizations are listed and described in Appendix A).

Press Releases-

Road superintendents in some towns have reported excellent results from a program of annual fall messages through the press (newspapers, radio, T.V.) reminding drivers of their role as winter approaches. The annual early-winter message should set forth general policies, highlight changes from the previous year, and remind citizens of their obligations. It can, for example, explain levels of service to be provided on different kinds of roads, remind citizens to think before driving during storms, and warn merchants (for example, parking lot operators) about ordinances prohibiting them from dumping snow into city streets. These messages should always mention the good work that maintenance departments perform, the dollar cost of these services to citizens, and the benefits to their tax rate of cooperation.

One annual message, however, is not enough. Special releases should be issued before and after major storms: before, to warn of the storm and remind citizens of their role; after, to report results. Again, these releases should always include information about the dollar costs of maintenance services and the benefits which citizens receive.

Maintenance managers may feel that the press will not be interested in such releases, which admittedly are not as dramatic as news about hurricanes and murders. But they should remember two points. First, citizens who patronize the press (buy newspapers, watch T.V., listen to the radio) are always interested in what may affect them, and weather is everyone's daily concern. Second, editors are always hungry for good "copy." They welcome it especially if presented in useable form, in other words in a form which requires only minor changes before being handed to the announcer or typesetter.

Learning the form of a press release is no more difficult than learning the form of a business letter or a short talk. In essence, "the lead" or beginning paragraph should contain the most newsworthy and important point you wish to make. Other points, one in each separate paragraph, follow in descending order of importance. Paragraphs should be short; so should sentences, and even words. A short quotation can often liven up the copy. Above all, write with the interests of the reader or listener in mind. The best way to learn the basics (and also to learn about your local media) is to seek advice from a working reporter or editor; a young one will be eager to expand his or her knowledge of government and to develop potential sources of future stories.

In a 1972 pamphlet, Don't Leave It All To The Experts, the U.S. Environmental Protection Agency offered 11 tips for working effectively with the press. Although written for voluntary citizen groups, these tips apply equally to any government agency which needs to tell its story to the public.

> "The press is in the news business. The environment is news. Responsible citizen organizations in the environmental field should and can be part of this news beat. If your group is not already known to the local press, consider these approaches:
>
> 1. Get to know the press. Make an appointment to see the editor, managing editor or city editor of your newspaper and the new director of your local television and radio stations. If you have any community leaders or other well-known individuals in your membership ranks (or an Advisory Committee), try to have one or two of them accompany you on the visit.

Tell the press about your organization's objectives, programs and membership. Explain how you might be able to help them from time to time--by interpreting the technical and scientific jargon of pollution control into lay language, by evaluating the success or failure of pollution control plans, by alerting them when key environmental decisions are forthcoming, by giving them newsworthy tips, etc.

Ask if there's a particular editor or reporter you should contact when you have a potential news story. Give them the name and telephone number of the person in your organization whom they can contact.

Ask for editorial support as well as coverage in news columns. Leave them with a brief (preferably one-page typewritten) description of your organization and its programs and add them to the mailing list for your newsletter, magazine, etc.

There's no substitute for this initial personal contact. It gives you and the press an opportunity to get to know each other. It gives you the opportunity to establish your credibility.

2. Maintain your credibility. This is vital for continuing good relations with the press. Your group must be responsible, responsive, and knowledgeable in dealing with the press at all times. Don't be evasive. If you don't know the answer to a question, say so -- and offer to get it and call back. Then do so, with the answer or with a frank statement that you don't know or couldn't get the answer. Don't guess. Don't speculate. If you're telling the press something off the record, make it clear that you don't want to be quoted. But don't use the off-the-record cover to peddle false or inaccurate information.

3. Learn press deadlines. Don't call them at deadline time unless you've got a truly "hot" item. Time your press release to meet their deadlines.

4. In your press releases and conversations with the press, avoid the jargon of pollution control [and snow and ice control]. Unless the reporter covers the environment full-time, chances are you know more about the subject than he does. Be helpful by talking and writing plainly.

5. Don't issue press releases or hold news conferences unless you really have something to say. If you hold a press conference, have a release and background material available and give the press a chance to go over it before the conference begins. Don't waste the press's time by simply rehashing the press release in your oral presentation. Allow plenty of time for questions. If you really have nothing to add to the release, or if the

subject doesn't lend itself to questioning, you shouldn't hold a press conference. And don't schedule press conferences at deadline times or in competition with other local major news developments.

6. Don't tell the press what to print or broadcast; that is their business and their decision. And don't expect the press to print or broadcast every word in your press releases. Settle for a part of the story.

7. When you issue a press release, deliver it personally if at all possible. If you have to mail it, call and alert the press that a release is in the mail and brief them on the content. Don't try to read the release to them unless they ask you to. Whenever possible, get the release to the press at least one or two days before the release date. (This will not be possible under certain circumstances, of course--such as a statement from your group in response to a control agency action, a polluter's action, a legislative action, etc.).

8. If an officer of your organization is making a speech somewhere, send a copy to the press at least a day or two before, with a press release or cover note. Mark the release and the speech for release at the time and date it will be given.

9. Don't argue with the press. If you think you have a grievance, discuss it with them privately and rationally. Don't attack the press. If you have an honest disagreement on a public policy, or an editorial opinion they've expressed, present your views in a letter to the newspaper editor. If it's a radio or television station, ask for an opportunity to reply through a taped editorial comment, broadcasting's version of the letter to the editor.

10. Be sure of your facts. If you mislead the press, you can destroy your credibility and public acceptance. And consequently, your ability to influence public opinion, government and industry.

11. Be resourceful. Look for opportunities for your organization and its programs to become part of local news events, not necessarily centered on the environment and thereby receive valuable visibility."

To summarize, maintenance managers do not use the press enough. Press releases are not difficult to write and issue. Editors are always interested in information and news useful for their readers and listeners. By giving editors good and timely releases, managers can greatly increase the chances of having them used.

Letters to Key Persons and Groups-

This technique was reported successful by the superintendent of a New Jersey town. It is in reality just a refinement of the press release, a communication directed at a specific sector of the public. As fall ends and winter begins, this superintendent writes a letter, perhaps mimeographed, to owners of such businesses as garages, used car lots, and markets. He reminds them of the town ordinance forbidding owners from plowing or dumping snow onto the streets, explains the department's policies for the coming winter, and requests their cooperation in specific ways. Similar letters might also be addressed to merchants and residents in congested areas, such as shopping districts, concerning parking as well as plowing.

Pamphlets and Fliers

Many or all households in a town might be reached most effectively by using a variation of the letter technique. One or another agency of town or city government sends some kind of message--tax bills, water bills, or voting information--to almost all households. It is a small matter to add to these envelopes a flyer or a small pamphlet carrying the maintenance message. The telephone company uses this technique skillfully with its monthly memo, which subscribers find when they open their bill. State Registries of Motor Vehicles, AAA, and citizens groups might also be willing to include such fliers or "stuffers" with their regular mailings for license renewals, newsletters, and the like. A "stuffer" for utility bills from Arlington, Massachusetts is shown in Figure 46.

For example, the City of Ann Arbor, Michigan recently published a six-panel, fold-out pamphlet (shown as Figure 47) to inform its citizens of the city's new snow and ice control program designed to reduce reliance on chemicals. Note that it includes a city map, highlighting the arterial routes to be salted. It also includes tips for safe winter driving, in cartoon form, and a summary of recommendations passed by the city council. Such pamphlets can be distributed at many public meetings, and also given to visitors to a department's snow-control center.

Larger than a flyer or pamphlet, but essentially the same idea, is the pocket guide. Vermont's Department of Highways developed a simple but effective shirt-pocket guide for all drivers of snow plows, reminding them of the Department's policies. The Salt Institute several years ago published a guide in comic-book form for the same audience. Managers, or perhaps state associations of maintenance officials, could publish such pamphlets specifically for cooperating government agencies, particularly the police, parks, sanitation, and fire departments, whose personnel are greatly concerned and effected by snow-removal policies. (These guides should be used in conjunction with personal talk by managers, especially to police troopers in their barracks, to explain policies and practices).

WE'LL DO OUR BEST, BUT WE'LL NEED YOUR HELP!!

Help us!
Please

For Better Snow Plowing This Winter,
We Would Appreciate Your Cooperation
By:

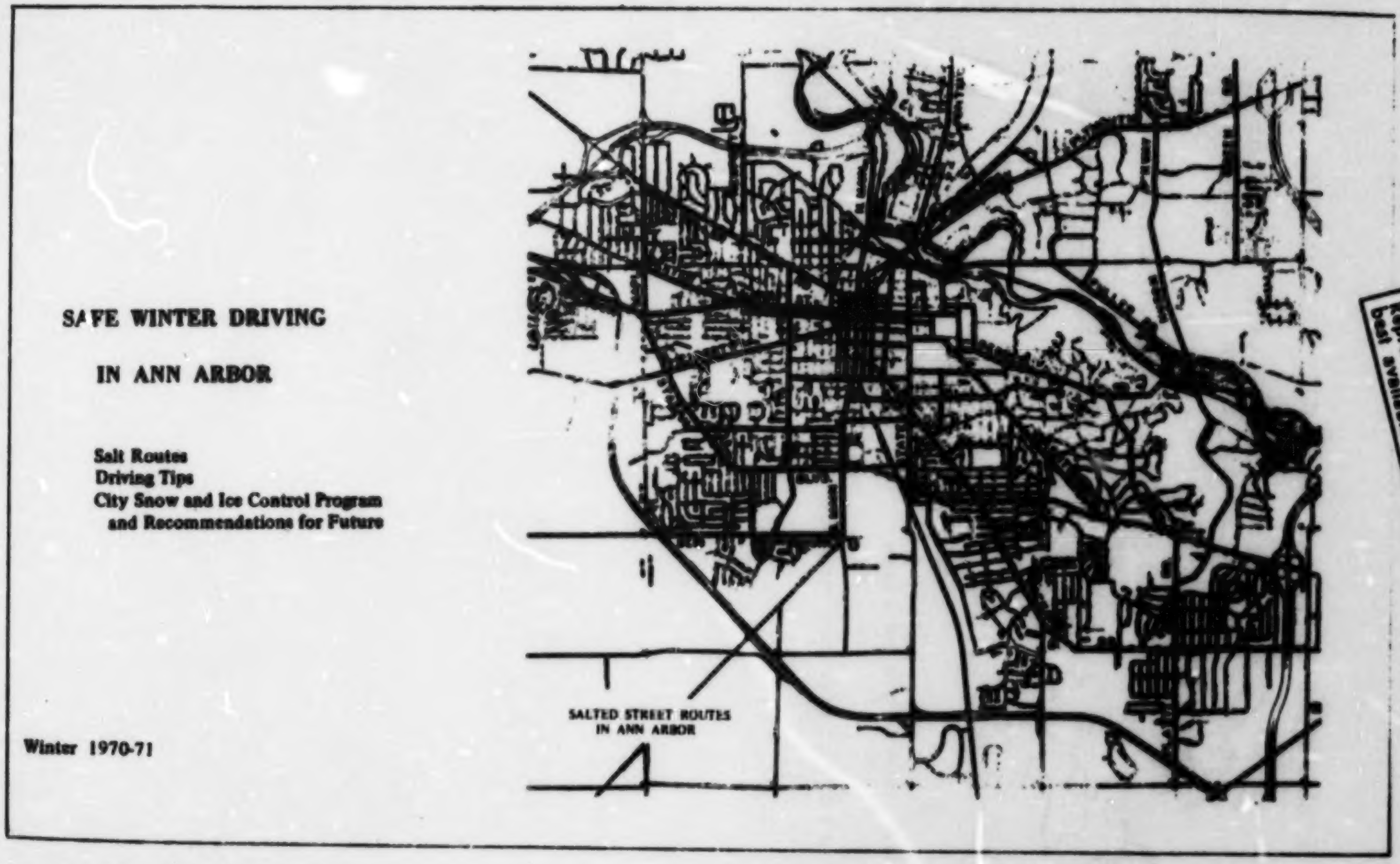
During a snowstorm, do not drive
unless ABSOLUTELY necessary.
Public transportation should be used
whenever possible.
Please park your car off the street.

PLEASE HELP US TO HELP YOU!!!!!

Courtesy of Town of Arlington, Massachusetts.

FIGURE 46 UTILITY BILL "STUFFER" CONCERNING SNOW AND ICE CONTROL

Reproduced from best available copy.



SAFE WINTER DRIVING

IN ANN ARBOR

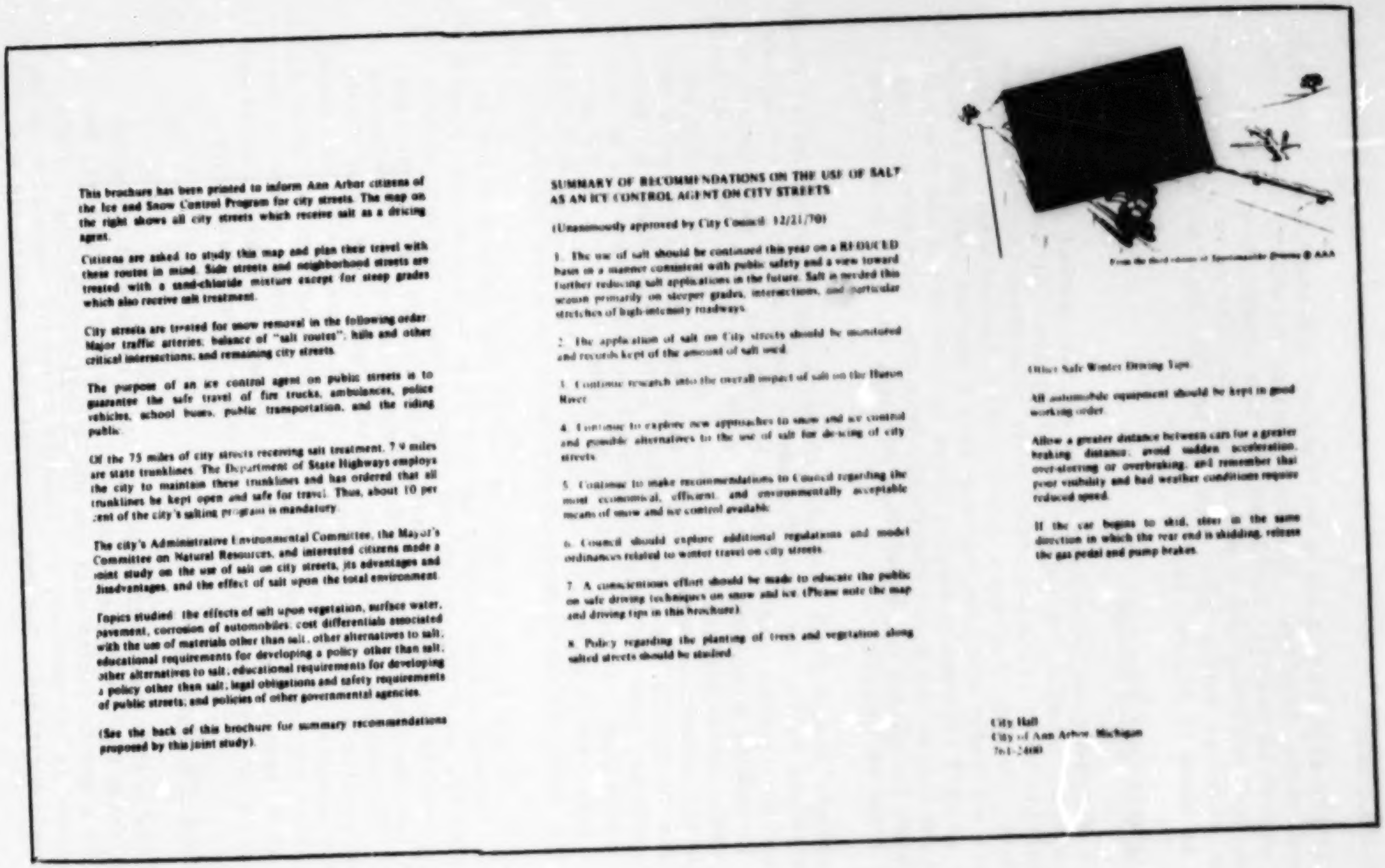
Salt Routes
Driving Tips
City Snow and Ice Control Program
and Recommendations for Future

Winter 1970-71

SALTED STREET ROUTES
IN ANN ARBOR

Courtesy of City of Ann Arbor, Michigan.

FIGURE 47 SNOW AND ICE CONTROL INFORMATION PAMPHLET



This brochure has been printed to inform Ann Arbor citizens of the Ice and Snow Control Program for city streets. The map on the right shows all city streets which receive salt as a deicing agent.

Citizens are asked to study this map and plan their travel with these routes in mind. Side streets and neighborhood streets are treated with a sand-chloride mixture except for steep grades which also receive salt treatment.

City streets are treated for snow removal in the following order: Major traffic arteries, balance of "salt routes", hills and other critical intersections, and remaining city streets.

The purpose of an ice control agent on public streets is to guarantee the safe travel of fire trucks, ambulances, police vehicles, school buses, public transportation, and the riding public.

Of the 75 miles of city streets receiving salt treatment, 7.9 miles are state trunklines. The Department of State Highways employs the city to maintain these trunklines and has ordered that all trunklines be kept open and safe for travel. Thus, about 10 per cent of the city's salting program is mandatory.

The city's Administrative Environmental Committee, the Mayor's Committee on Natural Resources, and interested citizens made a joint study on the use of salt on city streets, its advantages and disadvantages, and the effect of salt upon the total environment.

Topics studied: the effects of salt upon vegetation, surface water, pavement, corrosion of automobiles; cost differentials associated with the use of materials other than salt; other alternatives to salt; educational requirements for developing a policy other than salt; other alternatives to salt; educational requirements for developing a policy other than salt; legal obligations and safety requirements of public streets; and policies of other governmental agencies.

(See the back of this brochure for summary recommendations proposed by this joint study).

SUMMARY OF RECOMMENDATIONS ON THE USE OF SALT AS AN ICY CONTROL AGENT ON CITY STREETS

(Unanimously approved by City Council: 12/21/70)

1. The use of salt should be continued this year on a REDUCED basis in a manner consistent with public safety and a view toward further reducing salt applications in the future. Salt is needed this season primarily on steeper grades, intersections, and particular stretches of high-intensity roadways.

2. The application of salt on City streets should be monitored and records kept of the amount of salt used.

3. Continue research into the overall impact of salt on the Huron River.

4. Continue to explore new approaches to snow and ice control and possible alternatives to the use of salt for de-icing of city streets.

5. Continue to make recommendations to Council regarding the most economical, efficient, and environmentally acceptable means of snow and ice control available.

6. Council should explore additional regulations and model ordinances related to winter travel on city streets.

7. A conscientious effort should be made to educate the public on safe driving techniques on snow and ice. (Please note the map and driving tips in this brochure).

8. Policy regarding the planting of trees and vegetation along salted streets should be studied.

From the third volume of Sportsmanlike Driving © AAA

Other Safe Winter Driving Tips

All automobile equipment should be kept in good working order.

Allow a greater distance between cars for a greater braking distance, avoid sudden acceleration, over-steering or overbraking, and remember that poor visibility and bad weather conditions require reduced speed.

If the car begins to skid, steer in the same direction in which the rear end is skidding, release the gas pedal and pump brakes.

City Hall
City of Ann Arbor, Michigan
761-2400

FIGURE 47 CONTINUED

Posters and Exhibits

Only a little effort is required to translate information in a pamphlet into large visual displays. Posters reminding drivers of winter rules can be spotted on bulletin boards in the town square, high schools, churches, post offices, banks, and so on. The city of Arlington, Massachusetts, recently used a truck body for posting the signs with good effect, as shown in Figure 48.

Answering Telephone Inquiries

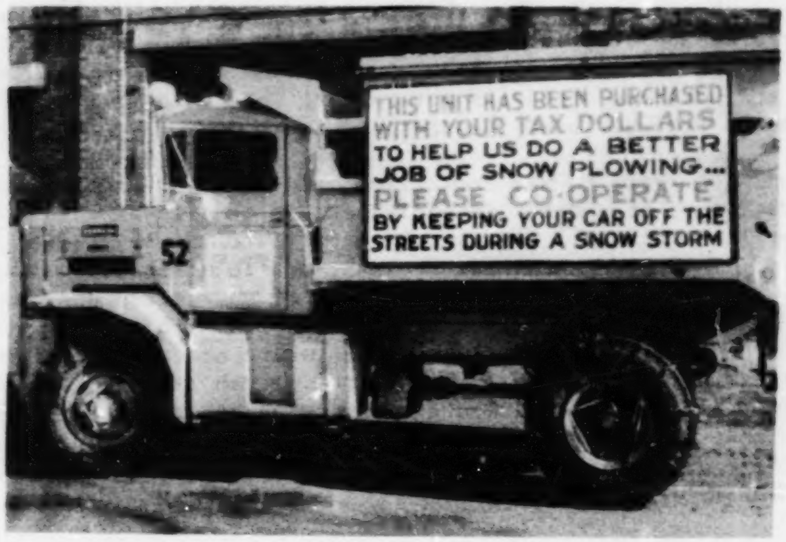
DPWs talk with many citizens who call to ask for weather information, request special service, or generally to complain. Citizens who show enough initiative to telephone undoubtedly talk about their experience with others, and are, therefore, automatically influential. (Similarly, newspapers and radio stations estimate that those who take the trouble to write or call represent probably three to five others who have the same thought but do not act.) Therefore, telephone relations with the public, even though not conducted face to face, are just as important as other types of contact.

Thus, a manager should think carefully about who in the organization should handle telephone calls, and how. The man or woman on the DPW's telephone should know the locality and its roads, be familiar with maintenance, be skillful in talking with people, and be authoritative in manner. Although the department serves the public, it cannot and should not blindly say "yes" to every request or demand, especially when men and equipment are under stress during a storm. The telephone person must know the department's priorities, know the stage of operations, and, therefore be able to tell callers when they are likely to be plowed out. But he or she should not make rash promises that trucks will find difficult to fulfill or that will cause political embarassment later for other officials.

The person on the phones can do much to ensure that rules will not be too rigid. Although a town or city may accept a reduced salting program in principle, the resulting delays and inconveniences may work serious hardship on certain persons, for example, elderly shut-ins, physicians, clergymen, and emergency workers such as ambulance drivers or telephone repairmen. The maintenance chief and his telephone communicator should be prepared to give a reasonable amount of special service to legitimate callers, for example, by plowing a doctor's street early or assigning a truck part-time for special and unexpected duties. Such service is the best form of an agency's public relations; it can also make a significant contribution to an environmentally-responsible snow-removal policy.

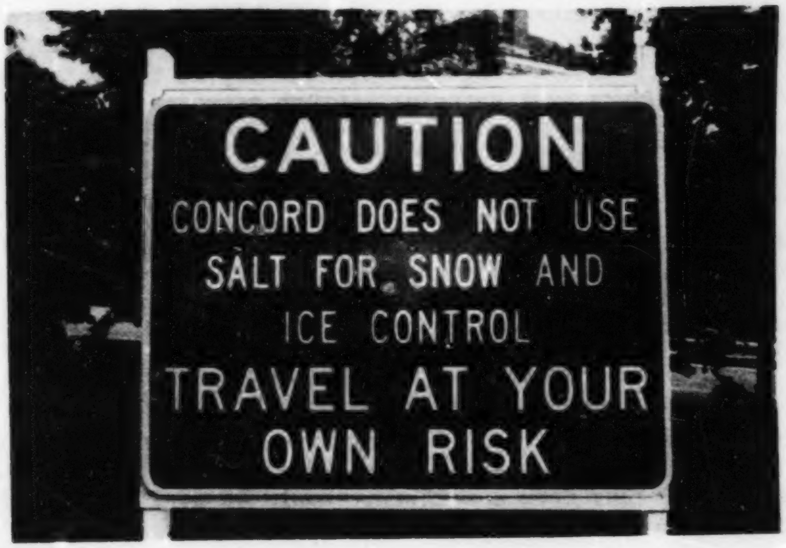
Signs on Roads and Highways -

All of the techniques described above are forms of general education, designed to shape the attitudes of drivers. These must, however, be reinforced by signs to remind citizens while they are driving. Signs can be important safety devices, for example to warn drivers of a coming change in road conditions. Two Massachusetts towns, Burlington and


THIS UNIT HAS BEEN PURCHASED
WITH YOUR TAX DOLLARS
TO HELP US DO A BETTER
JOB OF SNOW PLOWING...
PLEASE CO-OPERATE
BY KEEPING YOUR CAR OFF THE
STREETS DURING A SNOW STORM
52

Courtesy of Town of Arlington, Massachusetts.

FIGURE 48 SNOW TRUCK WITH EXPLANATORY SIGN


CAUTION
CONCORD DOES NOT USE
SALT FOR SNOW AND
ICE CONTROL
TRAVEL AT YOUR
OWN RISK

Courtesy of Town of Concord, Massachusetts.

FIGURE 49 WARNING SIGN

Concord, used them recently when they were experimenting with banning salt (Figures 49 and 50). (Both towns have subsequently reinstituted the use of salt in limited amounts). A more common sign on highways throughout the northern states is one warning that bridges freeze earlier than do road surfaces (Figure 51).

Signs reminding drivers to use snow tires, and possibly also chains, should be used more frequently in jurisdictions that require them by ordinance or law; this will assist police officers and judges in enforecement. In some mountainous regions, public officials go further — requiring instead of merely advising the use of snow tires and chains. Figures 52, 53 and 54 from California are examples. This technique can be used effectively, however, only on roads where access is limited, as in mountain passes, where road crews and police can halt vehicles and inspect them. Similar potential usage exists on other controlled-access highways, such as toll roads like the New York Thruway and the Massachusetts Turnpike, where vehicles can be halted at toll plazas until daugerous conditions abate.

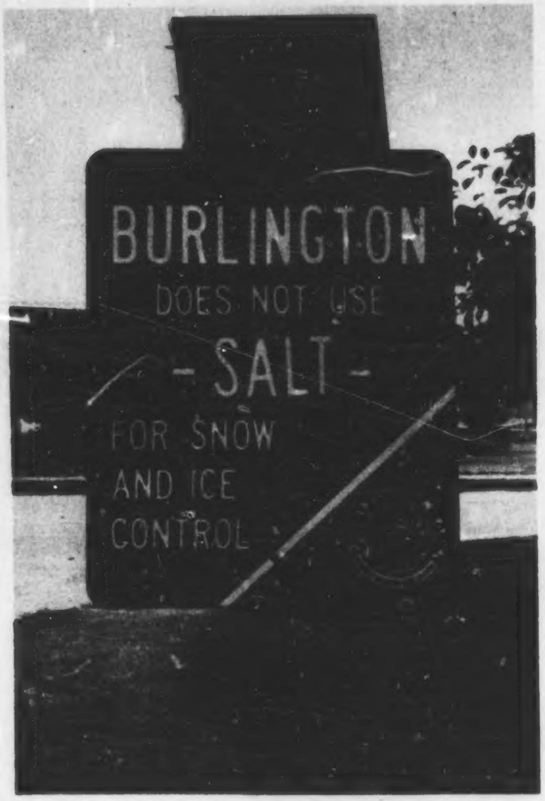
Vermont has adapted this technique for its sections of interstate highways. Figure 55 shows an advisory sign placed beside the access ramp to I-89. It can be adjusted by hand: the upper half of the pole sits loosely in the lower half, so that the local highway crew man can turn it to face entering traffic during dangerous conditions and turn it away again during normal weather. These signs are only advisory, however, and not enforced by police. Vermont authorities have not conducted research to learn whether these signs appear to influence driver behavior; but they do report from experience that the signs would better be placed beside the interstate highway itself, just at the ned of the ramp's acceleration lane, to remind through drivers already on the main line as well as to warn drivers just entering. Other states should consider adopting Vermont's practice.

Information-Getting Techniques

As the preceding list suggests, it is important to tell citizens about maintenance policies, in the hope that they will behave cooperatively. But any service organization must also receive information from its customers about the forms and quality of its service.

Complaints-

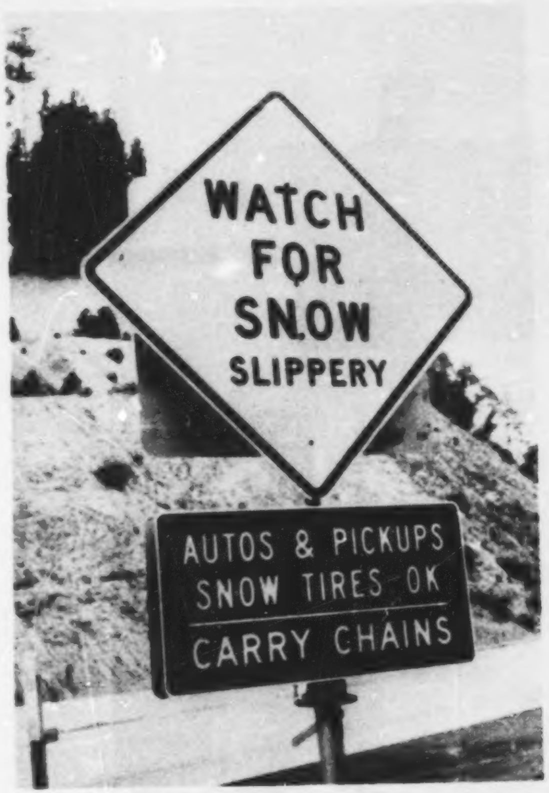
These are the most obvious sources of information from citizens. Some may seem irritating, crazy, or irrational. Some may be disregarded. But others, especially if they form a pattern, should be considered with care as a signal for a possible adjustment in policy and practice.


BURLINGTON
DOES NOT USE
-SALT-
FOR SNOW
AND ICE
CONTROL

Courtesy of Town of Burlington, Massachusetts.

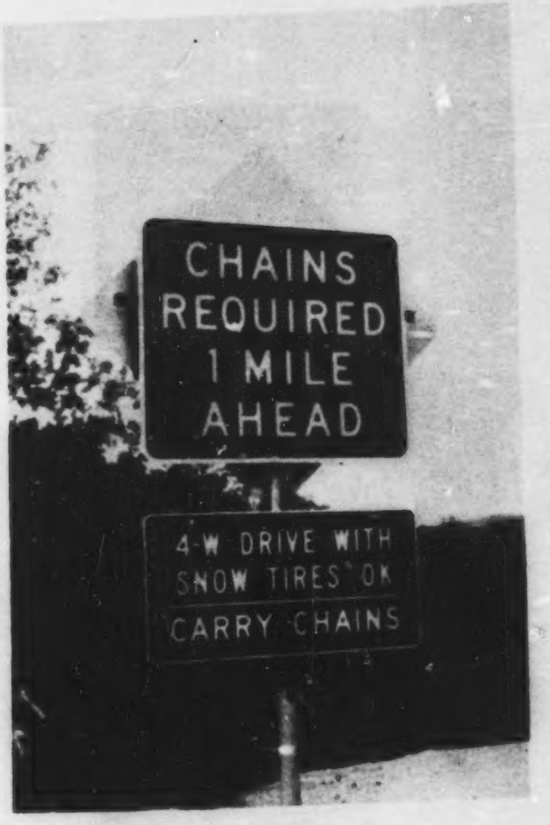
FIGURE 50 WARNING SIGN

FIGURE 51 WARNING SIGN AT BRIDGE


WATCH
FOR
SNOW
SLIPPERY
AUTOS & PICKUPS
SNOW TIRES OK
CARRY CHAINS

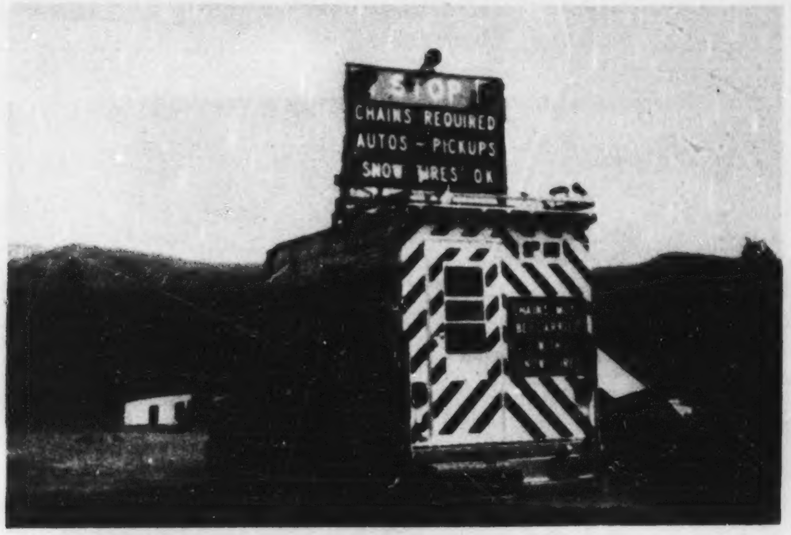
Courtesy of State of California Department of Transportation.

FIGURE 52 REVERSIBLE SIGN: SLIPPERY CONDITIONS WARNING SIDE


CHAINS
REQUIRED
1 MILE
AHEAD
4-W DRIVE WITH
SNOW TIRES OK
CARRY CHAINS

Courtesy of State of California Department of Transportation.

FIGURE 53 REVERSIBLE SIGN: CHAINS ADVISORY SIDE


STOP
CHAINS REQUIRED
AUTOS - PICKUPS
SNOW TIRES OK

Courtesy of State of California Department of Transportation.

FIGURE 54 TRUCK EQUIPPED WITH SNOW WARNING SIGNS

Courtesy of State of Vermont Department of Highways.

FIGURE 55 SAFE MAXIMUM SPEED LIMIT SIGN

Scan the press -

Some information about citizen attitudes and needs is likely to appear in the daily press. Comments may be direct, as in letters about specific problems, or in editorials or columns. Some information may come indirectly, in news reports of tie-ups or comments at town meetings.

Surveys -

Research techniques developed in universities have long been used by businesses, for example, to learn about their markets. Local governments are increasingly using survey methods, including mailed questionnaires, interviews, and systematic observations, to obtain detailed information about the needs of their citizen constituency. The mechanical traffic counter, used by highway planners to gather data for origin-destination studies, is a form of survey familiar to engineers. Such techniques could be used by maintenance officials to learn the preferences of a community for various snow-fighting tools and various levels of service. DPWs could conduct mail surveys by including questionnaires in other town or city mailings, as described above in our discussion of "pamphlets," or they might enlist cooperation of Conservation Commissions or voluntary citizen environmental groups to conduct interview surveys. A variation useful in small towns is to publish the questionnaire in the local newspaper and request readers to return it by mail.

Public Hearings -

This form of obtaining citizen views has become familiar during the past decade. For example, hearings are required for reviewing environmental impact statements and water pollution control plans. Maintenance officials can use them as a device both for proposing their policies and for learning public reactions. Before initiating the hearing process, they should consult other government officials who have already conducted hearings in order to learn about the steps required for running them successfully.

Exchange or Inter-action Techniques

One-way communications are not enough to ensure citizen cooperation. Clearly, a number of the information-giving and information-getting techniques can be used for two-way communication; we shall not repeat them here. Most of the other interaction techniques need only be listed to be recognized.

Informal versions of public hearings include meetings between maintenance officials and other officials or private citizens in community meetings, with citizen advisory groups, or during citizen meetings on other environmental questions. For example, maintenance managers might ask citizen environmental leaders to convene an advisory panel to review and comment each fall on policies planned for the coming winter. Conservation officials or knowledgeable citizens can be included in annual fall training programs for maintenance crews, to encourage direct give-and-take between truck drivers and citizen drivers. Citizen leaders can be invited to observe storm-fighting operations, both in the snow control center and on the road with crew chiefs, to learn the range of difficulty which maintenance personnel face. (This, by the way, would make a good newspaper feature article.)

Use of these interaction techniques should not be limited to non-government persons only. They should also be employed in relations between all sectors of the maintenance manager's world. They can be just as effective with environmental officials, public health officers, and police officers, as with citizens. The results of communicating with your various publics using these techniques can be many. Managers can develop support for higher appropriations, for example to finance salt storage sheds and improved spreader equipment. Managers can learn from public health officials or ground water hydrologists which areas are especially sensitive to side effects of chemicals, and probably obtain advice in devising procedures for special treatment; this has been done by state officials in Connecticut. They can develop, with citizen help, simple programs for monitoring the effects of maintenance policies on the environment and on citizen attitudes. Ordinary drivers should become more aware of practical problems facing maintenance crews. Perhaps most specifically, outside advisors can help maintenance managers in deciding which levels of service should be provided to which roads or areas, and in resolving the inevitable conflicts that surround these choices.

Laws, ordinances, and regulations are also, as we noted at the beginning of this discussion, important tools for citizen education. All of the techniques described above can be used during the process of developing regulations and laws, as well as in administering them effectively. For example, towns may not legally need to pass by-laws to conform with state laws; but conservationists have found this a useful device for focusing the attention of citizens. For a fuller discussion of the legal and institutional framework within which maintenance managers work, see Part One, "Institutional Interactions."

THEMES AND MESSAGES

The previous discussion has concentrated on tools and techniques, although some of the important messages have been mentioned in passing. In this final section, a number of messages which seem important are set forth explicitly. These were drawn from suggestions by maintenance personnel, officials of other government agencies, citizen conservationists, and our own observations.

Is this Trip Necessary?

One useful lesson of the gasoline shortage during the winter of 1973-74 was that people can indeed reduce their traveling, for example by combining trips and by car pooling. For years since the end of World War II, our economy of plenty, especially our ample supply of cheap fuel, has encouraged drivers to assume that they can travel anywhere at will.

In addition, man's apparent ability to shape and control nature's environment to suit his own convenience has encouraged the assumption that drivers can travel any time at will, regardless of weather and road conditions. But now we are being forced to recognize some limits, imposed by such factors as safety, environmental degradation, cost of fuel, and costs of maintaining roads during winter. Snow plow drivers who watch inexperienced drivers and fools slithering helplessly into snow banks naturally ask, "Is this trip really necessary?" Every winter, maintenance managers should be reminding all drivers to ask this question of themselves before every trip in stormy weather.

Drive Slowly on Hazardous Roads

This caution, although obvious, needs to be repeated often, and in various ways. One snow-plow driver for the State of New Hampshire put it well in a slogan: "It is better to be late, Mr. Motorist, than to be the late Mr. Motorist!" One benefit of slowing down appeared as a by-product of the national policy to reduce fuel consumption in 1973-74 by lowering the speed limit to 55 miles per hour: during the months that followed, according to National Safety Council reports, the rates of accidents and fatalities dropped significantly.

Only Service which is Reasonable

Since 1950, maintenance departments have striven and generally succeeded in providing excellent levels of service to drivers. They did so for a variety of reasons, in addition to the normal duty to serve: the dramatic increase in numbers of cars and trucks, their growing importance in the economy, the explosion of cities into suburbs, growth of population and affluence, decline of railroads and mass transit forms of transportation, and the advent of salt and other deicing chemicals as convenient and effective ice-fighting tools. The enthusiasm about chemicals, by drivers as well as by maintenance workers, led naturally to the concept of "bare pavements" as the standard of service. The appealing notion of "June travel in January" raised expectations that bare pavements would be available at almost all times - night and day, in bad weather as well as good. Such concepts have economic importance, for example to markets receiving supplies by truck and for ski resorts receiving customers by car while snow is falling. Maintenance departments have responded to these demands well.

In fact, they have responded perhaps too well for their own peace of mind. Few citizen drivers realize the dollar costs of such high levels of wintertime service. Only in recent years have we begun to recognize the environmental costs of heavy reliance on chemicals. As most maintenance managers know from their jangling telephones, some citizens are all too quick to complain when roads are less than bare.

Both DPWs and citizens must recognize more generally that maintenance departments cannot provide services without regard to costs, both dollar costs and environmental costs. In other words, they can provide service only at reasonable levels. These levels of service must be clearly understood both by maintenance crews and by citizen drivers, far more so now than in the past. Only by mutual recognition of these stated standards will maintenance managers be able to feel less defensive and less harassed.

Snow Routes

If various levels of service are to be provided, it follows that particular routes will be better for traveling at particular hours. The public should know of them.

Bare Roads are Not Necessarily Safe Roads

The assumption that "bare roads are safe roads" is comforting but slippery. It has seemed a valuable rule-of-thumb for maintenance foremen; and it was certainly a valuable selling point for salt salesmen. But the idea is slippery insofar as it leads people to assume that roads are the only factor in highway safety. Clearly, the road and its condition is only one component of the system of "moving people and goods from here to there." Other parts of the system include weather, vehicles, and drivers. All are obviously important influences on safety. A clear, dry pavement is indeed preferable to a slippery, icy pavement. But drivers can drive at hazardous speeds in January as well as June, and be encouraged to do so by pavements that are clear.

It does not follow that roads covered with ice or snow are in themselves unsafe. They are unsafe only if drivers travel over them without due caution. (Incidentally, just as mariners must observe a general rule of good seamanship, drivers must observe the law that requires them to exercise good judgment in relation to conditions of road and weather. Specific requirements of law and regulation, in the form of posted speed limits, can at best only set the outside limits of behavior; within these limits, drivers must exercise discretion and judgment to suit changing conditions.)

The point that bare roads are not necessarily safe roads is important in the relations between maintenance department and their publics. Maintenance departments can only suffer from the sloppy thinking and sloppy language which suggests that, first, bare roads are somehow safe roads, and therefore second, that maintenance men are responsible for highway safety. They can be responsible for maintaining pavements in certain conditions; but they are not, and cannot be, responsible for all the components that influence highway safety. Although this statement seems obvious when written here, it seems to be forgotten during the stress of an accident investigation, when many persons find it convenient to point the finger of blame at road conditions and maintenance men. DPWs have responsibility, to be sure, but with limits which must be defined clearly. Clear standards of responsibility are necessary for good management, cooperation with other government departments, and healthy relations with citizens.

In some communities, especially smaller ones, candid discussions about such problems with environmental groups might result in them taking the initiative in citizen education as part of the groups' regular program.

Over-Salting is Dangerous

The ample natural resources that Americans have long taken for granted leads them to accept easily an argument that says, in effect: "If some is good, then more must be better." Only in recent years are we beginning to recognize that this logic may be fallacious.

Maintenance men with experience know that over-salting can defeat the purpose of salting. One result, during a storm, can be "slippery slush," which increases the hazards of driving. Another, after a storm, can be a residue of chemicals on the road surface; at certain places, for example low spots or shaded spots, and under certain conditions, when quickly rising temperatures of vegetation can release moisture, the deliquescence of a chemical agent such as calcium chloride can attract moisture that may freeze on contact with the colder road pavement, and thus form a thin, but hazardous, layer of ice. In addition, of course, abuse of salt and other chemicals can increase dollar costs of replacing spalled concrete, dead trees or shrubs, and contaminated water supplies.

Maintenance men should by now recognize most of these dangers. Our point, however, is that citizen drivers should learn about them also, so that they will moderate their expectations and demands for service.

Cooperation can be Reinforced by Coercion

We argued earlier that cooperation is not merely nice, but also necessary. Our discussion here has assumed that many or most drivers can and will cooperate with maintenance authorities if they are shown why and how. However, we recognize that not all drivers will comply. The police powers of government are part of the maintenance manager's arsenal of tools. He cannot use them himself, but police officers and other officials with police powers can use them in his behalf. Drivers as taxpayers should enjoy the benefits of well-maintained winter roads. But drivers as citizens also have obligations to observe laws and regulations devised for the common good, for example, limiting speed, limiting snow routes, and limiting levels of service. Maintenance managers, as part of their program of public education, should explicitly remind drivers of these obligations.

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APPENDIX A

ORGANIZATIONAL RESOURCES FOR CITIZEN EDUCATION

Listed below are a selection of organizations, by name or by type, both national or local, that can assist in developing a program of citizen education and cooperation. The national offices listed can direct you to their state and local chapters or affiliates; they can often supply or suggest useful literature and audio-visual aids. In addition, look for similar kinds of local organizations or informal groups, which can offer local knowledge and resources of great value. To locate key persons in private organizations, begin by contacting the Environmental Chairman of your nearest League of Women Voters.

General Federation of Women's Clubs. 1734 N St., N.W., Washington, D.C. 20036. An organization of 51 state federations of local women's clubs and clubs in 53 foreign countries. Supports study and action programs for community betterment. Departments include conservation, education, home life, public affairs, international affairs and the arts. Publishes program materials for members.

Sierra Club. 1050 Mills Tower, 220 Bush St., San Francisco, Calif. 94104. Membership organization of 140,000 in 41 chapters. Active in legislation and litigation at all government levels devoted to the full range of environmental problems. Publishes scientific and educational studies concerning all aspects of man's environment and natural eco-systems.

The Garden Club of America. 598 Madison Ave., New York, N.Y. 10022. National organization of member clubs which promote knowledge and appreciation of conservation, horticulture and landscape design.

Izaak Walton League of America. Room 806, 1800 North Kent St., Arlington, Va. 22209. A membership organization of citizens, founded 50 years ago, which has grown to a national organization with 600 chapters. Chapter members work in their own communities and are dedicated "to the restoration and wise use of all our resources." The League assists chapter and state divisions with information, literature and professional staff services. From its earliest history the League has compaigned in legislative efforts aiding state and federal water pollution control agencies.

National Wildlife Federation. 1412 Sixteenth Street, N.W., Washington, D.C. 20036. Develops and makes available information packet, including publications list and sample publications, for primary, junior high, senior high, and college levels; publishes weekly "Conservation Report" reflecting Congressional action on environmental issues.

National Audubon Society. 950 Third Avenue, New York, N.Y. 10022. Membership organization with 260 local chapters. Works for conservation of all natural resources and conservation education. Special programs for Nature Centers Planning Division provides technical assistance in planning and operation of community nature centers. Offers field staff assistance on cost-share basis. The Society publishes bi-monthly magazine, newsletters, bulletins and teaching aids, publications list. Offers films and speaker services.

U.S. Environmental Protection Agency. Office of Public Affairs, 401 M Street, S.W., Washington, D.C. 20024. Establishes and enforces environmental standards; conducts scientific studies into the causes and effects of pollution, techniques of pollution control, and environmental consequences of man's actions; provides technical and financial assistance to state, regional and local jurisdictions; publishes a wide variety of environmental literature.

League of Women Voters of the United States. 1730 M Street, N.W., Washington, D.C. 20036. 160,000 members in state and local chapters. Provides information at the local level on environmental problems and developments in the community; provides information on how to influence decision-making. Contact local League of Women Voters listed in the telephone directory, or write national headquarters for name of your state leader.

Keep America Beautiful, Inc. 99 Park Avenue, New York, N.Y. 10016. Conducts ongoing public education programs to encourage a sense of individual responsibility for a quality environment, encouraging litter control as the first step toward solving other pollution problems; coordinates activities at state and local levels through four regional field offices; designs, through its Program Development Department, special ecology programs for businesses, industry, government, etc., upon request; provides information on environmental improvement projects; sponsors public service campaigns through the Advertising Council to fight pollution.

The Conservation Foundation. 1717 Massachusetts Avenue, N.W., Washington, D.C. 20036. Studies environmental issues and publishes findings in monthly 12-page report, CF Letter; each issue is devoted to comprehensive discussion of one topic; prepares publications in all areas of conservation and provides information on relevant publications developed by other sources; maintains rental/purchase collection of films and filmstrips on conservation.

Regional EPA Directories. A number of EPA's Regional Offices (listed below) have compiled directories of the environmental organizations within their multi-state areas. For additional information contact the Public Affairs Director.

Regional Office	States Covered
Boston, Mass. 02203 617-233-7223	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
New York, New York 10007 212-264-2515	New Jersey, New York, Puerto Rico, Virgin Islands
Philadelphia, Pa. 19106 215-597-9370	Delaware, Maryland, Pennsylvania, Virginia, West Virginia, D.C.
Atlanta, Ga. 30309 404-526-3004	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
Chicago, Ill. 60606 312-353-5800	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin
Dallas, Texas 75201 214-749-1151	Arkansas, Louisiana, New Mexico, Oklahoma, Texas
Kansas City, Mo. 64108 816-374-5495	Iowa, Kansas, Missouri, Nebraska
Denver, Colo. 80203 303-837-4905	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming
San Francisco, Calif. 94111 415-556-6695	Arizona, California, Hawaii, Nevada, American Samoa, Guam, Trust Territories of the Pacific, Wake Island
Seattle, Wash. 98101 206-442-1203	Alaska, Idaho, Oregon, Washington

Federal Highway Administration, National Highway Institute. This federal unit was recently organized to provide training assistance to state and local highway officials. It may in time offer assistance in citizen participation and education.

American Automobile Association. 1730 Pennsylvania Avenue, N.W., Washington, D.C. 20006. This membership association with many state affiliates has a Department of Environmental Affairs in its Washington office.

The Salt Institute. 206 North Washington Street, Alexandria, Virginia 22314. This trade association, representing the interests of the salt producing companies, has recently developed public information materials in connection with its "sensible salting" campaign.

The following are types of state and local organizations that can contribute in the form of counsel, skilled manpower, public meetings, and publications media (a few inquiries by telephone should lead quickly to exact names and addresses):

State Highway Associations

Associations of City Managers, Town Selectmen, Township Supervisors, and other senior officials of local governments

State Municipal Leagues or Associations

State County Leagues or Associations

Local or Regional Natural Resources Councils

Conservation Commissions. These arms of local government, recently established in six northeastern states, possess powers and responsibilities delegated by their state legislatures through enabling legislation. With the passage of some state-level environmental protection laws, such as the Inland Wetland Act in Massachusetts, the authority of Conservation Commissions is likely to increase. Their members may have considerable experience with both local environmental problems and citizen education.

Directories of Organizations and Specialists. In addition to the nationally-known organizations described above, maintenance managers can identify other resources through several directories, available in major libraries or directly from their publishers:

- Directory of Environmental Information Sources, Charles E. Thibeau, editor, Boston: National Foundation for Environmental Control, Inc., 1972 (2nd edition), 457 pp. Lists many organizations as well as articles, studies, etc.

- Encyclopedia of Governmental Advisory Organizations, Detroit: Gale Publishing Co., 1973, ca. 300 pp. A comprehensive reference guide to the many boards, panels, and groups which regularly advise government officials and agencies. Supplements issued annually.

- Water Quality Training Institute, The Conservation Foundation, Washington, D.C., conducted for the U.S. Environmental Protection Agency in 1974 a nation-wide series of meetings about the citizen participation required by the Federal Water Pollution Control Act of 1972. The excellent loose-leaf manual written and assembled by the Foundation includes a 170-page section, "On Technical Assistance," consisting of names, titles, and addresses of about 2,500 scientific and technical specialists, listed by state, willing to advise on water quality questions.

- Conservation Directory, A List of Organizations, Agencies, and Officials concerned with the Natural Resource Use and Management. Annual publication of the National Wildlife Federation, 1412 Sixteenth Street, N.W., Washington, D.C. 20036.

Similarly, other organizations may have networks or lists of cooperating specialists available to assist maintenance managers.

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16. ABSTRACT

This report contains the results of a study conducted for the U.S. Environmental Protection Agency to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Based on the best current practices for highway maintenance as observed during two years of study, practical guidelines are presented for the use of deicing chemicals.

1. Supervisory aspects of proper chemical usage are defined, including organization and personnel training.
2. Efficient snow and ice control requires good judgment and appropriate action. Elements of proper decision-making are discussed, including weather forecasting, setting chemical application rates, and accounting for chemical usage.
3. The backbone of winter road maintenance is equipment. General requirements and major equipment classes are described, including recent improvements and advantages or disadvantages. Methods are given for accurate spreader calibrations.
4. Means are described for developing and enlisting the support of citizens and drivers for winter road maintenance policies.
5. Legal requirements for and constraints on snow and ice control are described.

17. KEY WORDS AND DOCUMENT ANALYSIS

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